

**DEVELOPMENT AND QUALITY EVALUATION OF
MEAT FLOSS FROM BEEF, CHEVON AND PORK**

BY

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ABSTRACT

Meat Floss (MF) is a meat product traditionally produced from beef. The MF is a shredded meat product that is light, easy to pack and nutrient retaining. However, information on yield and nutritional quality of MF has not been well documented. Therefore, MF from beef (MFB), chevon (MFC) and pork (MFP) were developed and evaluated for yield and quality.

The raw beef, chevon and pork were obtained from thigh muscle and analysed for Dry Matter (DM) and Crude Protein (CP). The samples were cooked, shredded, fried for production of MF (MFB, MFC and MFP) and analysed for Product Yield (PY), DM and CP using standard procedures. Eating Qualities (EQ): aroma, flavour, tenderness, juiciness and texture were determined using a 9-point hedonic scale. Shelf stability of MF when differently packaged in acrylic bottle, polyethylene and polyamide for 21 days were assessed by measuring levels of Thiobarbituric Acid Reactive Substances (TBARS) using standard procedure. Based on EQ for MFB, *Semi tendinosus* (St), *Semi membranosus* (Sm) and *Bicep femoris* (Bf) obtained from raw beef were used to produce MF from St (MFSt), Sm (MFSm) and Bf (MFBf) using soya oil and their PY, CP and EQ were assessed. The TBARS levels of MFSt, MFSm and MFBf stored for 21 days in polyethylene were assessed. The most acceptable was used to produce MF using groundnut oil (GNO), soya oil (SOY) and palm oil (PMO) as frying media. The TBARS levels and Microbial Load (ML) of MF using GNO (MFGNO), SOY (MFSOY) and PMO (MFPMO) stored in three packaging media for three weeks were assessed. Data were analysed using descriptive analysis and ANOVA at $p=0.05$.

The DM (%) of raw beef, chevon and pork were 28.0, 33.3, 35.8 and their CP (%) were 22.9, 21.2 and 22.7 respectively. The PY (g/100g) of MFB (70.1) and MFC (74.1) were higher than MFP (68.9). The CP (%) of the products were 39.8, 46.7 and 41.8 for MFB, MFC and MFP respectively. The EQ for MFB (7.4) was higher than MFC (6.6) and MFP (6.2). The TBARS (mg/100g) levels were MFB (2.4), MFC (2.8), and MFP (2.0). The PY (g/100g) were 53.9, 63.9 and 64.1 and CP (%) were 40.1, 36.6 and 37.9 for MFSt, MFSm and MFBf respectively. The EQ was significantly higher in MFSt than both MFSm and MFBf. The TBARS (mg/100g) levels were 1.8 (MFSt), 0.7 (MFSm) and 1.5 (MFBf).

There were no significant differences in PY, CP and juiciness of MF from the three oil types. Though all the products were rated same in overall acceptability, MFPMO was most tender (6.4) and MFISOY was best in flavour (5.9). The TBARS (1.5 mg/100g) and ML ($1.3 \log_{10}^2 cfu/g/cm^2$) of MFISOY were highest irrespective of packaging media while TBARS (1.3) and ML (1.1) of polyethylene were low irrespective of the product. Meat floss contained about twice the protein in their respective raw meat and can be produced using any of groundnut oil, soya oil and palm oil. The products can best be kept in polyethylene.

Keywords: Meat floss nutritional quality, thiobarbituric acid reactive substances level, frying media, eating quality.

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CERTIFICATION

I certify that this work was carried out by Olayemi Rashidat KASSIM in the Department of Animal Science, University of Ibadan, under my supervision.

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DEDICATION

This work is dedicated to Almighty Allah, The Beneficent, The Merciful who has counted me worthy of HIS mercies and grace among HIS creatures and to my late grandmother, Mrs. Lucia Jeremiah, who believed and has long prayed for the success of this programme.

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Chapter One

1.0 Introduction

1.1. Meat, the first-choice source of animal protein

Meat is the most valuable livestock product and, for many people, it serves as the first-choice source of protein. It is either consumed as a component of kitchen-style food preparations or as processed meat products (Heinz and Hautzinger, 2007).

Meat is a valuable nutritious food that if untreated will spoil within a few days (Fellow, 2008). It is an ideal medium for many organisms as it provides a suitable environment for proliferation of meat spoilage microorganisms especially bacteria and common food-borne pathogens (Adzitey *et al.*, 2010). Meat products or processed meats are the result of the need to preserve meat in ancient times because not all the meat, suddenly available, could be eaten at once. The remaining part was processed to preserve the meat for later consumption. Therefore, meat processing originates in the need to preserve meat (Vandendriessche, 2008) and make it available over a long period.

Meat processing, also known as further processing of meat, is the manufacture of meat products from muscle meat, animal fat and certain non-meat additives. Additives are used to enhance flavour and appearance of products.

Meat processing can create different types of product composition that maximize the use of edible livestock parts and are made tasty, attractive and nourishing. Unlike fresh meat, many processed meat products can be made shelf-stable, which means that they can be kept without refrigeration either as canned heat sterilized products, fermented and slightly dried products or products where the low level of product moisture and other preserving effects inhibit bacterial growth.

Such shelf-stable meat products can conveniently be stored and transported without refrigeration and can serve as the animal protein supply in areas that have no cold chain provision.

Meat processing adds value to final products. The value-added meat products display specific flavour, taste, colour or texture components, which are different from fresh meat (Heinz and Hautzinger, 2007). Some of these processing methods also alter the flavour and texture of meat, which inevitably can increase its value when the products are sold (Fellow, 2008).

Meat yield is the main quality parameter in the processing of meat because it determines the amount of available product for sale and is therefore of direct economic importance. The sensory quality of the processed product has an indirect economic importance because it influences, most especially, how often a consumer buys the same product again, which expectedly, would influence the amount of product sold (Aaslyng, 2002). Quality indicators in the raw meat that can predict the yield of the processed meat are especially pH and water-holding capacity, whereas the sensory quality of the processed meat can be influenced by the colour, the meat/fat distribution and the fat quality in the raw meat (Aaslyng, 2002).

Consumers concern for meat and meat products have greatly increased during past decade (Min and Ahn, 2005). This will greatly influence the quantity of the raw meat and meat products purchased. Lennernas *et al.* (1997) reported that quality and healthfulness are among the most important factor that influences the choice of consumers for foods.

Research and development on value-added meat products are limited. A literature search on nutritional information on local meat and meat products revealed some food consumption data/information and isolated research papers on nutritional quality of such local meat products. With the consumption of processed meat products on the increase, it is pertinent to monitor the qualities of such food products.

Recently, interests are centered on pre-rigor processing of meat and production of intermediate moisture meat (IMM). IMM are low in moisture contents (Egbunike and Okubanjo, 1999) and are described as meat product having less than 20% moisture. One of such dehydrated product is called meat floss. It is the most important fresh meat substitute in China where refrigeration is not available (Ockerman and Li, 1999). Meat floss has its ally in other countries such as Meat floss has its ally in other countries as 'Machana' in Mexico, 'Rou song' in China, 'Moo yong' in Thailand (Wikipedia 2008) and 'Danbunama' in Northern Nigeria (Ogunsola and Omojola, 2008). Meat floss is a product that is developed as a means of preserving cooked meat in the absence of refrigeration facilities by the Hausa/Fulani people of the Northern Nigeria (Ogunsola and Omojola, 2008). It is a product processed principally from the semitendinosus portion of cattle (beef). It has good nutritive value and relative shelf life stability at room temperature. They are light weighted, easy to pack, ready to eat and can serve as snacks (Ockerman and Li, 1999).

Since little information is available about this product, it becomes expedient that the gap be filled and adequate information provided.

1.2 Statement of problem

- Meat floss is produced mainly by local women in Northern part of Nigeria without much attention to the hygiene and quality control.
- The production of meat floss is limited to the use of 'choice' and expensive cut from bull with attendant high price of the product.
- Meat floss production technique and its nutritive value are not adequately documented.

1.3 Justification

- Meat floss is not popular in Nigeria and there is little information on its processing and nutrient composition.
- Meat floss is classified as an intermediate moisture meat (IMM) whose keeping quality and the appropriate packaging material need to be evaluated.
- Meat floss will provide a value-added product to the consumers thereby enhancing their animal protein intake.

1.4 Objectives of the study

- To assess the production and consumption pattern of meat floss.
- To quantify yield and nutrient composition of meat floss as affected by different meat types
- To quantify yield and organoleptic characteristics of meat floss prepared from different muscle types.
- To evaluate the effects of oil types on qualitative variations, nutrient composition and shelf stability of meat floss.
- To assess the shelf stability of meat floss differently packaged.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Meat, a nutrient dense and highly perishable natural food

All natural foods like all other living materials are subject to processes of deterioration and decay (Egbo *et al.*, 2001). These gradual changes in fresh food are partly due to chemical changes in the living protoplasm of the food itself (Brian and Allan, 1981), which is usually catalysed by the cell enzymes, and partly due to changes caused by minute organisms (microbes) which gets into food from outside (external source) (Egbo *et al.*, 2001).

Meat is a high energy type of food and it is considered to be the food choice due largely to its nutritional value (Jihad *et al.*, 2009). It is an excellent source of many nutrients, especially protein, vitamin B, iron and zinc, in addition to its high quality protein content (Jihad *et al.*, 2009).

The meat shelf life and its keeping quality are reduced because it is nutrient dense and highly perishable due to the presence of conditions that favour the growth of microorganisms in the meat itself. Egbo *et al.* (2001) identified that processing will help to circumvent this undesirable situation and extend the shelf life of meat. Processed meat include those in which the properties are modified by the use of one or more procedure like grinding, chopping, addition of seasoning, heat treatment, drying and other processing or preservative processes (FAO, 1995). Such processed meats are commonly referred to as intermediate moisture meats (IMM). The production of IMM has great applications in space travels and other circumstances where stability, palatability and carrying-convenience of meats are essential (Wolter *et al.*, 2000).

Lowering the moisture content (dehydration) to prevent foods from spoilage is a well-known method in tropical areas. Such dried meat products are known as *biltong* in South Africa, *charqui* in South America, *pemmican* in North America, *tassajo* in Uruguay and *dendeng* in Indonesia (Lawrie, 1985). Since these dried meat products are stored under unrefrigerated conditions for long time, they are suitable and distributable nutritious foods that are readily available in tropical countries (Priyo *et al.*, 1987).

2.2 Types of Processed meat products

Meat products can be broadly grouped into six based on the processing technologies used, taking into account the treatment of raw materials and individual steps.

A. Fresh Processed Meat Products: This is a type of meat product where the meat and non-meat ingredients are added fresh. These are meat mixes products composed of comminuted muscle meat with varying quantities of animal fat. Products are salted only, curing is not practiced. Non-meat ingredients are added in smaller quantities for improvement of flavour and binding in low-cost versions, while larger quantities of non-meat ingredients are added for volume extension. Heat treatment (cooking and frying) is applied immediately prior to consumption to make the products palatable. Examples include fried sausages, patties, kebab, etc (Plate 1). Chicken nuggets can also come under this group because it has similar processing technology except that they are already fried in oil at the manufacturing stage during the last step of production (FAO, 2010).

B. Cured meat cuts: These are made of entire pieces of muscle meat and can be subdivided into two groups viz: cured-raw meats and cured-cooked meats. The curing for both groups is similar in principle, with the meat pieces treated with small amounts of nitrite, either as dry salt or as salt solution in water.

- i. Cured-raw meats: This does not undergo any heat treatment during manufacture. They only undergo a processing period which comprises of curing, fermentation and ripening in controlled climatized conditions that make the products palatable. The products are consumed raw/uncooked e.g cured-raw ham (Plate 2).
- ii. Cured-cooked meats: After the curing process of the raw muscle meat, it then undergoes heat treatment to achieve the desired palatability.

C. Raw-cooked meat products: The product comprises of muscle meat, fat and non-meat ingredients which are processed raw, that is, uncooked by comminuting and mixing. The resulting viscous mix/batter is portioned in sausages or otherwise, and thereafter subjected to heat treatment. During the heat treatment protein coagulation is induced which make the product to have a firm-elastic texture. This apart, the desired palatability and a certain degree of bacterial stability is achieved. Examples are viennas hot dogs, sausages and meat loaf of raw-cooked type (Plate 2) (FAO, 2010).



Fresh raw beef patties



Fresh fried sausages



Chicken nuggets

Plate 1. Some fresh processed meat products

Source: [www.fao.org.categories of processed meat products.html](http://www.fao.org/categories_of_processed_meat_products.html). Accessed 17/5/2012.



Cured-raw ham



Cured cooked products

Plate 2. Some cured meat products

Source: [www.fao.org.categories of processed meat products.html](http://www.fao.org/categories/processed_meat_products.html). Accessed 17/5/2012.



Vienna hot dogs



Sausages and meat loaf of the raw cooked type

Plate 3. Some raw cooked meat products

Source: www.fao.org/categories_of_processed_meat_products.html. Accessed 17/5/2012.

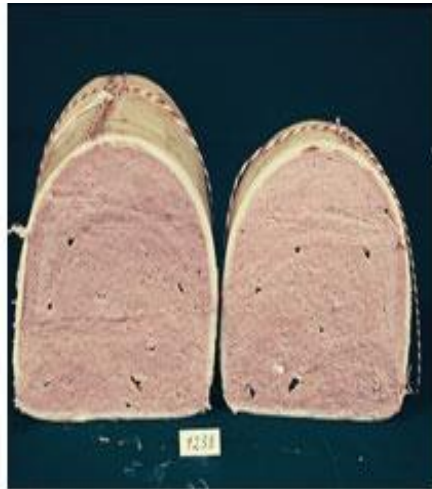
D. Pre-cooked Meat Products: These are type of meat products that contain mixes of lower-grade muscle trimmings, fatty tissues, head meat, animal feet, animal skin, blood, liver and other edible slaughter by-products. Two heat treatment procedures are involved in the manufacturing processes of this type of product. The first heat treatment is the precooking of raw meat materials and the second heat treatment is the cooking of the finished product mix at the end of the processing stage. These products are distinguished from other types of processed meat products by precooking the raw materials prior to grinding or chopping, and also by utilizing the greatest variety of meat, animal by-products and non-meat ingredients. Examples include blood sausage, liver pate and corned beef in cans (Plate 4) (FAO, 2010).

E. Raw-fermented Sausages: These are uncooked meat products that consist of more or less coarse mixtures of lean meats and fatty tissues combined with salts, nitrite (curing agent), sugars, spices and other non-meat ingredients filled into casings. They derived their characteristic properties (flavour, firm texture, red curing colour) through fermentation processes. The products are subjected to short or long ripening phases combined with moisture reduction (drying), in order to build-up the typical flavour and texture of the final products. The products are not subjected to any heat treatment during processing and are in most cases distributed and consumed raw. e.g. raw-fermented sausages, *Neem*, a fermented product from South-East Asia (Plate 5) (FAO, 2010).

F. Dried Meat Products: These products are derived through simple dehydration or drying of lean meat in a natural condition or in an artificially created environment. Their processing is based on the fact that dehydrated meat, from which a substantial part of the natural tissue fluid was evaporated, will not easily get spoilt. Pieces of lean meat without adherent fat are cut into specific uniform shape that permits the gradual and equal drying of whole batches of meat. Dried meat is not comparable to fresh meat in terms of shape and sensory and processing properties, but has significantly longer shelf life. Examples (Plate 6) are biltong from Southern Africa, meat floss (beef, chicken or pork) from Africa, East and South-East Asia, *kundi* in Nigeria (Omojola *et al.*, 2004).



Blood sausages



Liver pate



Corned beef in cans

Plate 4. Some pre-cooked meat products

Source: [www.fao.org.categories of processed meat products.html](http://www.fao.org/categories_of_processed_meat_products.html). Accessed 17/5/2012.



Raw fermented sausages



Neem, a fermented product from South Asia

Plate 5. Some raw-fermented sausages

Source: [www.fao.org.categories of processed meat products.html](http://www.fao.org/categories_of_processed_meat_products.html). Accessed 17/5/2012.



Biltong



Meat floss (beef, chicken and pork)

Plate 6. Some dried meat products

Source: [www.fao.org.categories of processed meat products.html](http://www.fao.org/categories_of_processed_meat_products.html). Accessed 17/5/2012.

2.3 Some common dried meat products

A. Charqui (Charki): This is defined as smoked and sun dried strips of beef or venison (International Dictionary of Food and Cooking, 1998). Also, the term is used synonymously with jerked beef, chipped beef, jerky and jerked meat. Charqui comes from South America, with much produced in Brazil, and differs from biltong in that it is a fatty product. A traditional approach to making charqui has many similarities to that used in the dry curing of bacon. The best grade final product contains 20-35% fatty tissue.

B. Pemmican: Pemmican is a cold environment equivalent of other dried meat products, originally invented by the American Indians. It is described as consisting of dried meat of buffalo, caribou, deer and later beef, which was packed in melted fat into specially made raw hide bags. The meat was dried in the sun and pounded or shredded prior to being mixed with the melted fat. This preservation method is based on the air exclusion provided by the fat, which reduces oxidative changes and diminishes microbial growth. Pemmican can be flavoured and partially preserved by the addition of dried acidic berries. Sometimes, dried fruits such as currants are added to improve palatability and in warmer zones this product is refrigerated or heat processed.

C. Pastirma: Pastirma is a meat product made of salted and dried beef. It is highly esteemed in Turkey and Egypt as well as other Islamic countries (Leistner, 1987). It is also popular in some parts of the Soviet Union. In Turkey, it is produced from September to November when conditions are more favourable (low temperature, low humidity, absence of flies, etc). Meat from 5 to 6 years old beef cattle is used, taken from the hind-quarter within 6 to 12 hours of slaughter. The meat is cut into long strips (500 to 600 mm) with a diameter not more than 50 mm. The strips are rubbed and covered with salt containing potassium nitrate and several slits are made in the meat to aid salt penetration. The strips are then washed and air dried for 2 to 3 days in summer or 15 to 20 days in winter. After drying, the strips are piled up to 300 mm high and pressed with heavy weights for 12 hours. They are dried for a further 2 to 3 days and pressed again for 12 hours. Finally the meat is air dried for 5 to 10 days. After salting and drying, the surface of the meat is covered with a 3 to 5mm thick layer of a paste called cemen (containing

freshly ground garlic, helba, hot red paprika, kammon, mustard and water). Helba is used as a binder and the other ingredients are for flavour. The paste covered meat strips are stored in piles and dried for 5 to 12 days in a well-ventilated room. The end product has 30-35% moisture and can be stored at room temperature for 9 months.

D. *Tasajo*: *Tasajo* is a salted meat-based product made in Cuba as a version of charqui. Traditionally, the meat is salted then sun dried for at least three weeks. Industrially, it is made by wet salting in a saturated salt brine (1%) for 8 hours, dry salted, and finally hot air dried at 60°C until a 50% weight loss is achieved (Chenoll *et al.*, 2007).

E. *Nikku*: *Nikku* is a dried product eaten in the Canadian Arctic. It is one of a range of raw or partially cooked locally prepared traditional or country foods derived from wild game meat. Traditionally, *nikku* is made by cutting caribou meat into strips and hanging them in the sun until dried (Forbes *et al.*, 2009).

F. *Sou gan*: *Sou gan* are Chinese dried meat products of which at least 30 different variants are known (Leistner, 1995). They are valued for their flavour, storage (no refrigeration) and transport properties (light) as well as their nutritive value. Products vary according to the species of meat, the type of technology and the spices used. Water activity can lie between 0.6 to 0.9 (intermediate moisture food) or less than 0.6 (low moisture food). Three basic processes are used to achieve either dried meat slices, dried meat cubes strips or shredded dried meat.

G. *Biltong*: The production of *biltong* involves a series of steps including meat preparation, marination, and low temperature drying. The raw meat is tempered or thawed if it is frozen. Selected cuts of meat are then cut into long strips and fat is trimmed from the meat as it may go rancid during subsequent processing and storage. Once the meat strips have been prepared, there are a number of variations of the marination method. Salt is included in the spice mix in each case. Dipping is used in small scale manufacture but tumbling is used by larger producers. The meat can be hung up for drying immediately after dipping in the spices or it could be left resting in the mixture, preferably at refrigerated temperatures, and then removed and dried.

H. Jerky: Meat for making jerky can be pieces from whole muscle or pieces made from chopped and formed meat. Many different approaches have been suggested for preparing jerky but all include drying at an elevated temperature.

2.4 SPICES

Plants are primary sources of medicines, fibre, food, shelter and other items of everyday use by humans. The roots, stems, leaves, flowers, fruit and seeds provide food for animals and human beings (Hemingway, 2004). Plants serve as indispensable constituents of human diet supplying the body with minerals salts, vitamins and certain hormone precursors in addition to protein and energy (Oyenuga and Fetuga, 1975). Seeds have nutritive value and calorific value which make them necessary in diets (Odoemelam, 2005). Among these plant seeds/leaves, some are referred to and consumed as spices.

Spices are a group of esoteric food adjuncts that have been in use for thousands of years to enhance the sensory quality of foods. They can also be referred to as edible plant substances that possess antioxidative, antiseptic and bacteriostatic substances (Onyeagba *et al.*, 2004) and they can be added to food to delay the onset of deterioration such as rancidity (Lafont *et al.*, 1984). These spice ingredients impart characteristic flavour, aroma and color to foods (Srinivasan, 2005) while some, like fenugreek, can modify the texture of food. Not only are spices used as flavourings and seasonings, but many are also be used in perfumery, cosmetics and toiletries. In addition, several spices have long been recognized to possess medicinal properties such as tonic, carminative, stomachic antispasmodic and antihelminthic.

2.4.1 Nutrient composition of Spices

Spices are not only used individually, but also in the form of spice mixtures, to suit different tastes and dishes. The protein content in spices varies from 4.5% in rosemary leaves to 31.5% in mustard, and the fat level varies from 0.6% in garlic to 42.6% in mustard. The ash content also varies from 2.3% in marjoram to 16.7% in basil leaves, reflecting high mineral levels in them. Some spices contain significant levels of vitamins and minerals, which cannot be ignored. A few spices are also rich sources of dietary fiber. Amongst common spices consumed, the dietary fiber is highest (43.3%) in red pepper. Nonetheless, black pepper (27.8%), coriander (36.2%), cumin

(23.0%), fennel (28.7%), and fenugreek (33.5%) also are rich sources of both soluble as well as insoluble dietary fiber.

The components of spices responsible for the quality attributes have been designated as 'active ingredients' and in many instances they are also responsible for the beneficial physiological effects of spices. For instance, Tajkarimi *et al.* (2010) reported that the presence of eugenol and cinamic aldehyde which have preserving action specific to some spices and essential oils, increases the shelf life of meat products. They act as food preservative and prevent or control growth of micro-organisms, including pathogenic micro-organisms. Thirteen different spices were also evaluated by Kim *et al.* (2011) and the authors observed that several spices were found to have high levels of antioxidant capacity and total phenolic compounds. Moreover, the antioxidant capacity, total phenolic content and flavonoid contents of the 13 selected spices were different from each other. Among the selected spices, the clove, thyme and rosemary extracts exhibited higher DPPH radical scavenging activities. From their report, clove and turmeric were observed to have the highest total phenolic content and flavonoid content respectively. These results suggest that several spices extracts have potential as possible functional ingredients in meat products.

2.4.2 Health and Safety Aspect of Spices

Extensive animal studies carried out to evaluate the safety aspect of spices have indicated that even at much higher dietary levels (up to 100 times the normal intake), red pepper, black pepper and turmeric have no adverse effects on growth, organ weights, feed efficiency ratio, nitrogen balance, and blood constituents. The salient features of a variety of health beneficial physiological effects of common spices or their active principles are enumerated below.

A. Hypolipidemic/Hypocholesterolemic Effect

Some of the commonly consumed spices were naturally evaluated for a possible hypocholesterolemic action in a variety of experimental situations in both animals and humans by Srinivasan *et al.* (2004). They reported that spices like fenugreek, red pepper, turmeric, garlic, onion and ginger are effective as hypocholesterolemic agents under various conditions of experimentally induced hypercholesterolemia/hyperlipemia.

Curcumin and capsaicin, the active ingredients in turmeric and red pepper respectively, are also efficacious at doses comparable to calculated human daily intake. Turmeric and curcumin showed excellent hypocholesteremic effect in experimental animals (Srinivasan, 2005). According to Lin (1994), the anti-platelet aggregation, the antiplatelet adhesion and the antiproliferation properties of aged garlic extracts appear to contribute more to cardiovascular protection than do the hypolipidemic properties. Apart from the hypocholesterolemic effect of capsaicin, its beneficial effect on overall lipid metabolism under different conditions of lipemia was also reported (Sambaiah and Satyanarayana, 1982; Srinivasan and Satyanarayana, 1988).

B. Antilithogenic Effect

The antilithogenicity of curcumin and capsaicin is considered to be due to lowering of cholesterol concentration and enhancing the bile acid concentration, both of which contribute to lowering of the cholesterol saturation index and, hence, reduce crystallization. In addition to their ability to lower the cholesterol saturation index, the antilithogenicity of these spice principles was also be due to their influence on biliary proteins (Hussain and Chandrasekhara, 1994).

C. Antidiabetic potential

Diet has been recognized as a corner stone in the management of diabetes mellitus. As part of the dietary treatment of diabetes, spices, have also been examined in this direction and their efficacy reviewed. A considerable number of human experiments have also been carried out on this aspect in addition to experimentally induced animal diabetic models. Fenugreek, turmeric, or its active principle curcumin, onion or its active principle allyl propyl disulfide, garlic, and cumin were observed to improve glycemic status in diabetic animals noninsulin dependent diabetes mellitus (NIDDM) patients (Srinivasan, 2005). Garlic and onion are two other spices that have been widely used for their antidiabetic potential. Both these spices were reported to be hypoglycemic in different diabetic animal models and in limited human trials. The hypoglycemic potency of garlic and onion has been attributed to the sulfur compounds, namely di (2-propenyl) disulfide and 2-propenylpropyl disulfide, respectively (Kumudkumari *et al.*, 1995; Augusti and Sheela, 1996).

D. Digestive Stimulant Action

Spices are well recognized to stimulate gastric function. They are generally believed to intensify salivary flow and gastric juice secretion and, hence, aid digestion. Spice, like turmeric, was

reported to reduce the pungency of the food and irritation to stomach. Turmeric has the property of increasing the mucin content of the gastric juice. Spices such as ginger, mint, ajowan, cumin, fennel, coriander, and garlic are used as ingredients of commercial digestive stimulants as well as of home remedies for digestive disorders, like, flatulence, indigestion, and intestinal disorders (Platel and Srinivasan, 2004).

Animal studies have also revealed that a good number of spices, when consumed through diet, bring about an enhanced secretion of bile with a higher bile acid content, which plays a vital role in fat digestion and absorption (Sambaiah and Srinivasan, 1991; Platel and Srinivasan, 2000). Such spices include curcumin (turmeric), capsaicin (red pepper), ginger, cumin, coriander, ajowan, fenugreek, mustard, onion, and tamarind. Spices such as curcumin, capsaicin, piperine, ginger and mint have also been reported to stimulate pancreatic digestive enzymes like lipase, amylase, trypsin, and chymotrypsin, which play a crucial role in food digestion (Platel and Srinivasan, 2001). Thus, many of the common spices act as digestive stimulants by enhancing biliary secretion of bile acids, which are vital for fat digestion and absorption and by stimulating the activities of pancreatic and intestinal enzymes involved in digestion.

E. Antioxidant property

Antioxidants can delay or inhibit the oxidation propagation of oxidizing chain reactions in the oxidation process (Zheng and Wang, 2001). The antioxidant properties of spice principles of capsaicin, curcumin, and eugenol, have been documented in animal studies by Reddy and Lokesh (1994). These compounds inhibited lipid peroxidation by quenching oxygen free radicals and by enhancing the activity of endogenous antioxidant enzymes like superoxide dismutase, catalase, glutathione peroxidase, and glutathione transferase.

F. Antimutagenic and Anticarcinogenic Property

Food mutagens are formed under certain cooking and processing conditions. These harmful products can be modified by the presence of antimutagens in the foods. Spices that have antioxidant property can function as antimutagens. Since mutation is one of the mechanisms by which cancer is caused, an antimutagenic substance is likely to prevent carcinogenesis. Studies on smokers revealed that administration of curcumin (1.5 g/day) for 30 days resulted in a significant reduction in the urinary excretion of mutagens (Polasa *et al.*, 1991). Shalini and Srinivas (1990) also reported that turmeric protected DNA against lipid peroxide-induced

damage and against fuel smoke condensate-induced damage. Similar to curcumin, the active principle in turmeric, eugenol, found in cloves and sesamol isolated from sesame seeds are reported to produce antimutagenic effect by protecting the cell from damage to its DNA. Chemically, most of these compounds have a common phenolic structure, which helps in the detoxification of xenobiotics. Research on mustard has also shown to have antimutagenic properties (NIN Annual Report, 1993–1994).

Epidemiological studies have shown that higher intake of allium products (e.g. garlic) is associated with reduced risk of several types of cancers, especially stomach and colorectal (Fleischauer and Arab, 2001). Pungent vanilloids, especially [6]-gingerol, present in ginger (*Zingiber officinale*) have been found to possess potential chemopreventive activities. [6]-gingerol, a pungent phenolic compound present in ginger is also reported to be a potent inhibitor of nitrous oxide (NO) synthesis and also an effective protector against peroxynitrite-mediated damage in macrophages (Ippoushi *et al.*, 2003). These bioactive compounds of spices exert their anticarcinogenic effect by deactivating the carcinogens or by enhancing the tissue levels of protective enzymes in the body.

G. Anti-Microbial Activity

Garlic and onions have been reported to possess anti-microbial property. The sulfur-containing compounds from these plants act against both gram positive and gram negative bacteria (Carson, 1987). The extracts of garlic and onion are known to inhibit growth of many pathogenic fungi belonging to genera *Aspergillus*, *Candida* and other species (Carson, 1987). Other spices like nutmeg, saffron, cumin, and thyme also have anti-microbial potential.

In view of the beneficial physiological effects that spices exhibit, these food adjuncts deserve to be considered as natural and necessary components of our daily nutrition beyond their role in imparting taste and flavour to our food.

2.5 Some common spices

A. Allspice (*Pimenta dioica*)

Allspice takes its name from its aroma, which smells like a combination of spices, especially cinnamon, cloves, ginger and nutmeg. It is grown exclusively in the Western Hemisphere. The evergreen tree that produces the allspice berries is indigenous to the rainforests of South and

Central America where it grows wild. Allspice is the dried fruit of the *Pimenta dioica* plant. The fruit is picked when it is green and unripe and traditionally, dried in the sun. It has a warm and sweetly pungent flavour like the combination described above with peppery overtones. Volatile oils found in the plant contain eugenol, an antimicrobial agent (Riffle, 1998; Yaniv and Bacharach, 2005).

B. Anise (*Pimpinella anisum*)

Anise also called aniseed is a flowering plant in the family Apiaceae. Anise bears a strong family resemblance to the members of the carrot family that includes dill, fennel, coriander, cumin and caraway. Anise is native to the eastern Mediterranean region, the Levant and Egypt. Anise is a herbaceous annual plant growing to 3 ft (0.91 m) tall. The leaves at the base of the plant are long and shallowly lobed, while leaves higher on the stems are feathery pinnate, divided into numerous leaves. The flowers are white, approximately 3 mm diameter, produced in dense umbels. The fruit is an oblong dry schizocarp, usually called "aniseed". Anise is sweet and very aromatic, distinguished by its characteristic flavour. The seeds, whole or ground, are used in a wide variety of regional and ethnic confectioneries (Albert-Puleo, 1980; Philip, 1999).

C. Rosemary (*Rosmarinus officinalis*)

Rosemary is a woody, perennial herb with fragrant, evergreen, needle-like leaves and white, pink, purple or blue flowers, native to the Mediterranean region. It is a member of the mint family Lamiaceae. Rosemary is used as a decorative plant in gardens and has many culinary and medical uses. The leaves are used to flavour various foods like stuffings and roast meats. Rosemary is a popular Labiatae herb with a verified potent antioxidant activity. The antioxidant activity of rosemary is mainly related to phenolic diterpenes which are considered effective free-radical scavengers (Dorman *et al.*, 2003).

D. Cinnamon (*Cinnamomum verum*)

Cinnamon is a spice obtained from the inner bark of several trees from the genus *Cinnamomum* that is used in both sweet and savoury foods. It is native only to the island of Sri Lanka but now widely grown in the South East. Cinnamon bark is one of the few spices that can be consumed directly. Its flavour is due to an aromatic essential oil that makes up 0.5% to 1% of its composition. Other chemical components of the essential oil include ethyl cinnamate, eugenol

(found mostly in the leaves), beta-caryophyllene, linalool, and methyl chavicol. (Wondrak *et al.*, 2010).

E. Marjoram (*Origanum majorana*)

Marjoram is a cold-sensitive perennial herb or undershrub with sweet pine and citrus flavours. Marjoram is cultivated for its aromatic leaves, either green or dry, for culinary purposes. The tops are cut as the plants begin to flower and are dried slowly in the shade. It is often used in herb combinations. The flowering leaves and tops of marjoram are steam-distilled to produce an essential oil that is yellowish in color (darkening to brown as it ages). It has many chemical components, some of which are borneol, camphor and pinene. (Douglas, 2001; GRIN, 2011).

F. Turmeric (*Curcuma longa*)

Turmeric is a rhizomatous herbaceous perennial plant of the ginger family, Zingiberaceae. It is native to tropical South Asia and needs temperatures between 20 °C and 30 °C and a considerable amount of annual rainfall to thrive. When not used fresh, the rhizomes are boiled for several hours and then dried in hot ovens, after which they are ground into a deep orange-yellow powder commonly used as a spice in curries and other South Asian and Middle Eastern cuisine, for dyeing, and to impart color to mustard condiments. Its active ingredient is curcumin and it has a distinctly earthy, slightly bitter, slightly hot peppery flavour and a mustardy smell.

Turmeric is usually used in its dried, powdered form but it is also used in fresh form much like ginger. It has numerous uses such as fresh turmeric pickle, which contains large chunks of soft turmeric. Although most usage of turmeric is in the form of root powder, in some regions leaves of turmeric are used to wrap and cook food. This usually takes place in areas where turmeric is grown locally since the leaves used are freshly picked and this imparts a distinct flavour (Gregory *et al.*, 2008; Chan *et al.*, 2009).



Allspice berry



Allspice leaves



Anise leaves



Anise seeds

Plate 7. Some spices – Allspice and Anise

www.google.picture.spices.com. Accessed 15/5/2012.



Turmeric



Marjoram



Sage



Rosemary



Cinnamon

Plate 8. Some spices – Turmeric, Marjoram, Sage, Rosemary and Cinnamon

www.google.picture.spices.com. Accessed 15/5/2012

G. Onion (*Allium cepa*)

Onion is a famous spice commodity grown all over the world and consumed in various forms. It is cultivated mainly as a biennial, but some types are treated as perennials. It varies in shape, size and colour, due to intensive selection during domestication and natural hybridization. The distinctive flavour of alliums has established the plant as an essential part of the cuisine of the world. It is used as immature and mature bulbs, as vegetable and spice, as well as food for poultry and non-milking cattle. Onions can be eaten raw or cooked, mild flavoured or coloured bulbs are often chosen for salad. The importance of onion lies in the flavour that it imparts to various other dishes. A common onion contains 88.6-92.8% moisture, 0.9-1.6% protein, trace-0.2% fat, 5.2-9.0% carbohydrates, 0.6% ash and 23-38cal/100/g of energy. It contains vitamins D (0.3mg/100g), C (10.0mg/100g), riboflavin (0.05mg/100g), nicotine acid (0.2mg/100g), folic acid (16.0µg/100g), biotin (0.9µg/100g) and pantothenic acid (0.14mg/100g).

Among various free amino acids which vary greatly, glutamic and arginine are abundant in onion. The concentrations of these amino acids are higher at the centre of the bulb and decrease towards the outer scales. Onion is characterized by its distinctive flavour and pungency which is due to sulphur-containing compounds that are available in the scales of bulb (Brewster, 1994). Intact onion cells have no odour but when cells are disrupted, the enzyme allinase is released which hydrolyses the *S-alk(en)yl* cysteine sulphoxides to produce pyruvate, ammonia and many volatile sulphur compounds associated with flavour and odour. The tear-producing character of onion on cutting is known as lacrimatory factor. Lacrimator is formed enzymatically during the hydrolysis of *S-propenyl* cysteine sulphoxide (Lancaster and Boland, 1990). Besides being used as a condiment and spice for flavouring and enriching various cuisines, onion has been known for its high medicinal properties, which include;

- (a) It acts as a stimulant, diuretic and expectorant and mixed with vinegar, which is used in the case of sore throat.
- (b) Essential oil from onion contains a heart stimulant, increases pulse volume and frequency of systolic pressure and coronary flow.
- (c) Onion consumption lowers blood sugar, lipids and cholesterol.
- (d) Fresh onion juice has antibacterial properties due to allicin disulphide and cysteine compounds and their interactions.

(e) Anti-platelet aggregation effect in human and animal blood have also been reported due to regular consumption of onion (Baghurst *et al.*, 1977).

H. Garlic (*Allium sativum* L.)

This also belongs to the genus *Allium*. It is a herbaceous, perennial bulbous plants with typical leek odour. It originates from Central Asia and spread to Southwest Asia and the Mediterranean region. The bulb of garlic (*A. sativum*) is compound in nature, consisting of numerous bulblets, so-called cloves, of different sizes, and with the whole surrounded by layers of white scale leaves. The ovoid cloves are 3-4 sided with an acute summit, narrowed into a thread like portion of fibre and the base truncate. Each clove is separately enclosed in a white scale and covered with a pinkish-white scale. Garlic contains a wealth of sulfur compound that is most important for the taste. It is allicin (diallyl disulphide oxide) which is produced enzymatically from allicin (S-2-propenyl-L-cysteine sulfoxide) (Brewster, 1994). It also contains derivatives of gamma-glutamyl cysteine in the bulb that are present in considerable amount of about 4% based on the fresh weight and they are responsible for the characteristic garlic odour. Other compounds present in small amounts are flavonoids, steroids, and triterpene saponins from the β -sitosterol or F-gitogenin type. Researches on the properties/ importance of garlic have shown that it possesses anti oxidative properties and can be used to delay/retard the onset of rancidity (Kumolu-Johnson and Ndimele, 2011).

I. Ginger (*Zingiber officinale* Roscoe)

Root ginger is the edible rhizome or root part of the plant *Zingiber officinale* that belongs to the family Zingiberaceae. It bears yellow flowers and the edible part (the rhizome) resembles knotty, almost fingerlike extensions which grow down into the ground. Ginger root has a spicy yet aromatic taste and smell. The strong taste is due to the fact that it contains a mixture of phenolic compounds and essential, yet volatile oils, such as shogaols and gingerols. Ginger root is low in calories and is cholesterol free. It is a very good source of essential vitamins and nutrients such as Vitamin B₆ (Pyridoxine) and B₅ (pantothenic acid) (Sue, 2010).

J. African Nutmeg (*Monodora myristica*)

African nutmeg is a perennial edible plant of the Annanacea family. It is a berry that grows wild in the evergreen forests of the West Africa (Burubai *et al.*, 2009). The seeds are economically and medicinally important (Okafor, 1987). The kernel obtained from the seeds is a popular

condiment used as a spicing agent in African dishes (Ekeanyanwu *et al.*, 2010). The seeds are embedded in a white sweet-tasting pulp, and are most economically important part of the tree. They are aromatic and are used, after grinding to a powder, as a condiment in food. It provides flavour resembling that of nutmeg (*Myristica fragrans*). They are also used as an aromatic stimulating addition to medicine and snuff (Ekeanyanwu *et al.*, 2010). The powder can also be used as a stimulant to relieve constipation, and sprinkled on sores especially those caused by guinea worm (Burkill, 1985).

The most predominant elements in African nutmeg seeds are potassium, calcium, phosphorus and magnesium. A typical African nutmeg contain 14.7% moisture, 9.1% crude protein, 29.1% crude oil, 458Kcal/100g crude energy, 25.9% crude fibre, 2.3% ash and an acidity level of 8.3 (Burubai *et al.*, 2009).

K. Nutmeg (*Myristica fragrans*)

Nutmeg is the seed of the tree *Myristica fragrans*, an evergreen tree indigenous to the Banda Islands in the Moluccas (or Spice Islands) of Indonesia. It is roughly egg-shaped and about 20 to 30 mm long and 15 to 18 mm wide and weighing between 5 and 10 g when dried. Nutmeg is usually used in powdered form.

L. Cloves (*Syzygium aromaticum*)

The word clove is derived from 'clou' which means nail. It is a native of Indonesia but also grown in Zanzibar, Madagascar, India and Sri Lanka. It is an aromatic flower of a tree in the family *Myrtaceae*. Clove tree is an evergreen tree whose height ranges from 10-20m. The bark of the tree is gray whereas the leaves are dark green, elliptical, fragrant and shiny in appearance. Cloves spice contains essential oil (up to 15%), whose constituents are eugenol, eugenol acetate and β -caryophyllene. 100g of ground cloves contain 0.144g water, 6.783kcal energy, 0.126g protein, 0.123g ash and 0.421 total fat/lipid.



African nut meg with pod



African nut meg without pod



Ginger root



Sliced ginger

Plate 9. Some spices - African nut meg and Ginger
www.google.picture.spices.com Accessed 15/5/2012



Garlic bulbs



Garlic bulbs



Onion bulbs



Whole and ground nut meg

Plate 10. Some Spices – Garlic, Onion and Nut meg
www.google.picture.spices.com Accessed 15/5/2012

It is also rich in potassium (23.142mg), calcium (13.566mg), magnesium (5.544mg) and sodium (5.103mg) (Chinese herbal medicine, 2004). Eugenol has pronounced antiseptic and anaesthetic properties. Cloves, apart from being used for food flavouring, confectionery and aroma in variety cuisines, natural clove is also used in other industries for its medicinal and therapeutic values.

M. Curry leaf (*Murraya Koenigii*)

The curry leaf tree is indigenous to India and grows almost everywhere, barring the high altitudes of the Himalayas. The leaves of the curry plant are used as a flavouring ingredient or spice in cookery. The plant is an aromatic deciduous herb, which reaches a height of 5-6 meters and the trunk has a diameter of 40-cm. The tree has elongated roots and the leaves are oval or pinnate-shaped, normally about 2.5 cm (1 in) in length. The tree has small, aromatic, blossoms and shiny, dark berry-like fruits with poisonous seeds. Curry leaf imparts a distinct aroma and a tangy flavour to the food.

N. Thyme (*Thymus vulgaris*)

Thyme is used as fresh and dried herb in various cuisines due to its distinct aroma. This herb is available in many varieties such as lemon thyme and caraway thyme. The extract obtained is used in aromatherapy for its therapeutic and medicinal uses. Thyme extract is known for its antispasmodic, antiseptic, aromatic, anti-inflammatory and carminative properties.

O. Peppercorn (*Piper nigrum*)

Pepper comes from several species of a vinous plant. Fruit, called peppercorns, is the part used for spice. Peppercorns ground for use on the table and in cooking originally only came from India, but is now also cultivated in Indonesia, Malaysia, China, Sri Lanka, Madagascar and South America. The bush has a round and smooth jointed stem; dark green leaves which are smooth, broad, and have seven nerves in them; and small white flowers. The flowers become the berries which are harvested. From this bush, three types of peppercorn are harvested: black, green, and white. The differences in the peppercorns come from when the berry of the bush is harvested and how it is processed. **Black pepper** is the dried, unripe berry. The corns are wrinkled and spherical, about 5 mm (1/8 in) in diameter. **White pepper** starts out the same as the black but are allowed to ripen more fully on the vine. The outer shell is then removed by soaking the berries in water until the shells fall off, yielding a whiter, cleaner pepper. **Green pepper** is from the same fruit but is harvested before they mature.

Nutritionally beneficial and medicinally positive, pepper offers a unique flavour and a variety of uses. This master spice is versatile in all forms. It offers a vibrant flavour suitable for any dish. Pepper is used daily by most people and offers health benefits along with adding its unique flavour (Hill, 2004).

P. Salt

Salt is a generic term for compounds formed of ions such as sodium, potassium and chloride (CMC, 2012). Typically, the table salt is made up of sodium and chloride and is one of the oldest spices used and is a key component to humans, animals and plants. Its flavour is unique and versatile. Historically, the main reason for the addition of salt to food was for preservation. However, with the coming of refrigeration and other methods of food preservation, the need for salt as a preservative has decreased (He and MacGregor, 2007). Sodium levels, especially in processed foods remain high. The tastes and flavours associated with historical use of salt have come to be expected and the relatively low cost of enhancing the palatability of processed foods has become a key rationale for the use of salt in food (Van der Veer, 1985).

However, taste is not the only reason for the continued use of high levels of sodium in foods. For some foods, sodium still plays a role in reducing the growth of pathogens that spoil products (to reduce their shelf life) by creating an inhospitable environment, thus preventing rapid spoilage (and thus extending product shelf life). In other applications, sodium levels remain high because salt plays additional functional roles, such as improving texture.

Salt ability to decrease water activity is thought to be due to the ability of sodium and chloride ions to associate with water molecules (Fennema, 1985; Potter and Hotchkiss, 1995). Adding salt to foods can also cause microbial cells to undergo osmotic shock, resulting in the loss of water from the cell and thereby causing cell death or retarded growth (Davidson, 2001).

Salt can also play a role in the development of physical properties of foods that are beneficial for processing or developing final product qualities. For instance, salt levels play an important role in controlling the stickiness of some doughs, and eases the processing of some baked goods (Hutton, 2002). The recommended salt intake varies among individuals and their genetics, but a minimum of 500 mg and a maximum of 2400 mg per day is a good daily recommendation.



Cloves



Curry leaves



Thyme leaves



Red pepper



Black pepper

Plate 11. Some Spices – Cloves, Curry leaves, Thyme leaves, Red pepper and Black pepper

www.google.picture.spices.com Accessed 15/5/2012

Table 1: List of some spices and their common names

English name	Scientific/*Botanical names	Yoruba	Hausa
Pepper	<i>Piper nigrum</i> L.	Ata	Yaji
Maggi	Maggi	Maggi	Maggi
African nutmeg	<i>Monodora myristica</i> (Gaertn.) Dunal	Epa onje	Gadamia
Ginger	<i>Zingiber officinale</i> Rosc.	Ata ile	Shika
Garlic	<i>Allium sativum</i> L.	Ayu	Kafanua
Cloves	<i>Syzygium aromaticum</i> (L.) Merr. et L.M. Perry	Iyere	-
Curry leaf	<i>Murraya koenigii</i> (L.) Spreng.	Curry	Thyme
Thyme	<i>Thymus vulgaris</i> L.	Thyme	Thyme
Onions	<i>Allium cepa</i> L. var. <i>cepa</i>	Alubosa	Alubosa
Salt	Sodium chloride	Iyo	Gashiri

* Botanical names according to Rehm and Espig (1991)

2.6 Oils and fats

Oils and fats have been indispensable substances for mankind both in nutrition and industry. They are the most important energy sources in food and are necessary as functional constituents in human and other organisms. They are carriers of essential nutrients and are important to consistency and flavour in a large number of foods. Edible oils from plant sources are of important interest in various food and application industry. These oils are mainly used for cooking and for production of soaps, margarine, cosmetics, etc (Ong *et al.*, 1995). They provide character flavours and texture to food as integral diet components (Odoemelan, 2005). Vegetable oils had made an important contribution to the diet in many countries, serving as a good source of protein, lipid and fatty acids for human nutrition including the repair of worn out tissues, new cell formation as well as useful source of energy (Grosso and Guzman, 1995). There are various types of oil available in different countries but the most common ones found in Nigeria include palm oil obtained from *Elaeis guineensis* Jack, peanut/groundnut oil obtained from *Arachis hypogaea* L. and soya/soy oil obtained from *Glycine max* (L.) Merrill.

2.6.1 Common cooking oils

A. Palm oil (*Elaeis guineensis* Jack)

This is an edible plant oil derived from the pulp/mesocarp of the fruit of the oil palm (*Elaeis guineensis*) originating in tropical Africa. It is currently the second largest traded edible oil and accounts for about one-quarter of the world's fat and oil supply. It is naturally reddish in colour because it contains a high amount of beta-carotene. It is a common cooking ingredient in South Asia and the tropical belt of Africa and one of the few highly saturated (about 50%) oil. That is, it contains approximately equal amount of saturated and unsaturated fatty acids indicating that it is a vegetable fat with high oxidative stability. Amongst the saturated component, palmitic and stearic acids account for 45% and 50% of the total fatty acid respectively, while the unsaturated component is made up of 40% oleic and 10% linoleic acids. It is composed of fatty acids esterified with glycerol and a large natural source of tocotrienol (part of vitamin E family).

Research has shown that the cholesterol impact of saturated fats is affected by its amount at the Sn-2 position and despite the high palmitic acid content ($\approx 40\%$) of palm oil, only 13-14% is

present at the Sn-2 position. Resulting from this, palm oil behaves as healthful as olive oil in being cholesterol neutral because the high concentrate of oleic fatty acid Sn-2 position expresses mono saturates characteristics (Pramod, 2006; Inuwa *et al.*, 2011).

B. Groundnut oil (*Arachis hypogaea* L.)

Groundnut, also known as peanut or earthnut, is a native to a region in eastern South America (Weiss, 1983). The groundnut is a herbaceous plant that grows up to 30-60 cm high. It is grown as an annual crop principally for its protein rich kernels seeds and edible oil. The seeds are borne in pods which develop and mature below the soil surface (Atasie *et al.*, 2009). Runner varieties, the most common in the West Africa, are shorter and run along the ground for 30-60 cm (Asiedu, 1992). Peanut is now grown worldwide primarily as an oilseed crop (Bansal *et al.*, 1993). Groundnut oil is obtained from the groundnut seeds and it contains only a small proportion of non-glyceride constituents (Aluyor *et al.*, 2009). Its fatty acid composition is complex including saturated fatty acids accounting for a wide range of molecular weights. It is an excellent food oil with good flavour and high quality with its low free fatty acid value (Aluyor *et al.*, 2009). The oil consists of more than thirteen vitamins including A, B, C and E. It is rich in essential minerals such as calcium, iron, zinc and boron and consists of saturated fatty acid such as palmitic, stearic, arachidic and lignoceric acids, and unsaturated fatty acids such as oleic and linoleic acids (Inuwa *et al.*, 2011). Groundnut oil is characterized by low iodine and saponification number. The relative linoleic acid in groundnut oil is a major factor affecting variation in stability of the oil (Kabagambo *et al.*, 2005).

C. Soya bean oil (*Glycine max* (L.) Merril)

Soya bean is a legume specie that is native to East Asia. It is widely grown for its edible bean which has numerous uses. The plant is classed as an oilseed. Some 22% of oil produced in the world have been reported to be soya bean oil. Soybean oil is low in saturated fat and high in monounsaturated and polyunsaturated fats. Its polyunsaturated fat amounts to 55-67%, of which 80-90% is linoleic acid while 10-20% is α -linolenic acid. This is responsible for the high susceptibility of the oil to oxidation. Owing to the considerable unsaturated fatty acids content of soya oil, its triglyceride practically all contains at least two unsaturated fatty acids and about 25% of the glyceride contains linolenic acids. Soya oil is also rich in omega-3 fatty acids. Omega-3 fatty acids are believed to reduce the risk of heart diseases and may prevent

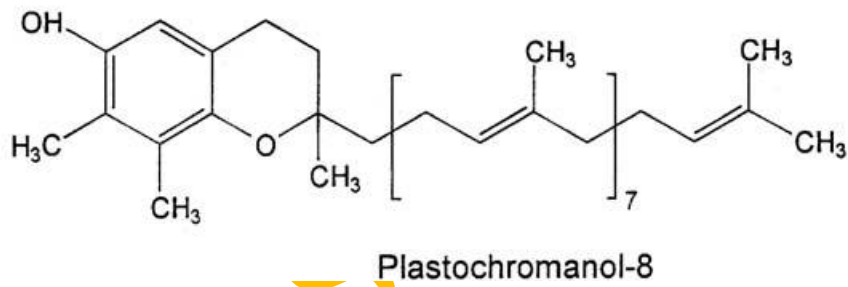
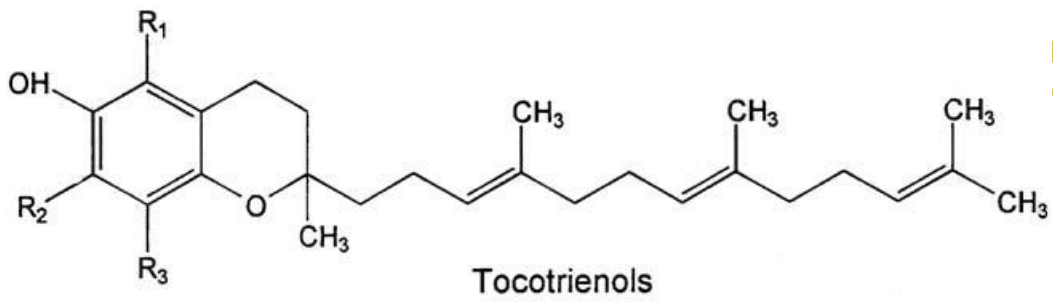
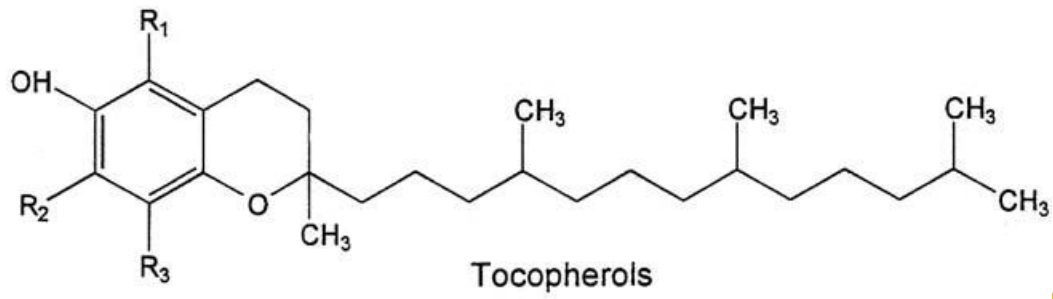
osteoporosis. Soya oil also contains phytosterols which could lower LDL cholesterol, but the oil does not contain cholesterol. According to USDA (2005) 100g of the oil contains 14.4g of saturated fatty acids, 23.3g monounsaturated fatty acid and 57.9g polyunsaturated fatty acid. It also contains linoleic (54.2g), oleic (20.4g), linoleic (7.7g), palmitic (9.6g) and stearic (3.5g) acids.

2.6.2 Tocopherols in oils

Tocopherols and its derivatives (tocotrienols and plastochromanol-8) are the natural antioxidants found in vegetable oils. Tocopherols are very important biological and nutritive food components in most vegetable oils (Minar *et al.*, 2003). They are integral components of the unsaponifiable matter present in most vegetable oils and fats, which are present in varying amounts depending on the oil. Tocopherols are natural antioxidants with important nutritional properties and their amount in plant is probably governed by the content of unsaturated fatty acids. They are used as food additives in prepared fats (Pocklington and Dieffenbacher, 1988). Tocopherols are present in different forms of isomeric forms. These compounds possess vitamin E activity and consumption of vitamin E has been shown to reduce the risk of coronary heart disease (Rimm *et al.*, 1993; Stampfer *et al.*, 1993) and heart attacks (Stephens *et al.*, 1996). Tocopherols, acting as antioxidants in oils, inhibit lipid oxidation which affects the nutritional quality, physical appearance and flavour of oil foods (Rathjen and Steinhart, 1997).

2.6.3 Iodine Value (IV) of Oils

An important characteristic of a fatty oil product is its iodine value (IV). This is a measure of the unsaturated fatty acid content and indicates the ease of oxidation or the drying capacity of the product. Empirically, the IV is expressed in terms of the number of grams of iodine per 100 gram of sample. One application of the iodine number is the determination of the amount of unsaturation contained in fatty acids. This unsaturation is in the form of double bonds or triple bonds which are very reactive with iodine compounds. The higher the iodine number, the more unsaturated fatty acid bonds are present in a fat and the more reactive, less stable, softer and more susceptible to oxidation and rancidification is the oil or fat (Firestone, 1994; Encyclopedia Britannica, 2012).



NB: R1, R2 and R3 have combinations of (CH₃, CH₃,CH₃), (H, CH₃, CH₃), (CH₃, H, CH₃), and (H, H, CH₃).

Figure: 1. Structures of tocopherols, tocotrienols and plastochromanol-8

Source: Williams (2011)

2.7 Types of cooking

In cooking, two basic methods are applied. The methods are classified as dry heat cookery and moist heat cookery, based on the way food is cooked and the type of heat that is used.

2.7.1 Dry heat Cookery Methods

In dry heat cooking methods, water is not used to cook the food. The food is left dry when heat is applied to cook it. Such methods of cooking are baking, steaming, grilling, and roasting. When heat is applied to the food, the food cooks in its own juice or the water added to the food during its preparation evaporates during the heating process and gets the food cooked. Heat is applied directly to the food by way of convection, thus making the food to get cooked. The action or movement of air around the food cooks it. Examples include;

1. **Baking:** This is cooking in an oven in most cases. The oven temperature ranges from 148°C to 240°C. Baking applies to the cooking of food made from batter or dough. Such foods include bread, cakes, cookies and pasteries.
2. **Roasting:** This is a method of cooking food uncovered in hot air at a temperature that usually ranges between 149-177°C. With roasting, direct heat is applied to the food. The heat seals the outside part of the food and the juice inside the food cooks the food. Roasting is mainly used when cooking fleshy food like fish, meat or chicken. When heat is applied to the outer covering of the food, it seals it up thereby trapping all the juices inside the food. Direct heating, heats up the juices inside the food, which then cooks the food. Again there is very little nutrient lost and the flavour is not spoilt. Food is frequently rotated over the spit so that there will be heating of all parts of the food.
3. **Broiling and Grilling:** These are cooking by direct application of heat. In broiling, the food lies directly under a continuous heat source. The meat is usually placed on a rack in a shallow broiler pan and the surface of the food lies 8-13 cm (3-5 inches) under the flame in a gas range broilers or below the broiler heating unit in an electronic oven. To prevent the air in the oven from becoming too hot while in grilling, the food lies directly over the heat source.
4. **Steaming:** This is the cooking of food in steam. It is used mostly to cook vegetable. For instance when steaming vegetable, the vegetable is placed on a rack or perforated pan in a sauce pan and water is added to the saucepan. The water collects below the rack or perforated pan,

hence the vegetable remains out of the liquid. Steaming takes longer time than boiling however, steamed vegetables for instance retain better colour and flavour than boiled vegetable. They have more nutrients because certain vitamins, including vitamin C, dissolve easily in water and may be removed during boiling.

2.7.2 Moist Heat Cookery Methods

In moist heat cookery methods, liquid is used as a medium to cook the food. Such medium could be water, coconut cream or oil. These liquids are added to the food before heat is applied to it or sometimes heat is applied to the liquid before the food is added into the cooking utensils to be cooked. The moist heat cookery methods include: boiling, stewing, shallow frying, deep frying, barbequing and basting.

1. **Boiling:** This is the cooking of food by boiling in water at the boiling temperature of about 100°C. It is the most common and simplest method of cooking. With this method of cooking, enough water is added to food and it is then cooked over the fire. The action of the heated water makes the food to get cooked. During the heating process, the nutrients can get lost or destroyed and the flavour can be reduced .

2. **Simmering:** This is the cooking of food in water that is just below the boiling point.

3. **Stewing:** In this process of cooking, food is cooked using a lot of liquid. Different kinds of vegetables are chopped, diced or cubed and added to the pot. This method is also used when preparing fruits that are going to be served as desserts. With this cooking method, every food is cooked together at the same time in one pot. The flavour, colours, shapes and textures of the different vegetables that are used, makes stewing a handy method of cooking.

4. **Barbequing:** It is most suitable to cooking meat cutlets, fish or chicken pieces. The food is usually marinated with spices and tenderizers (for meat cuts) for sometime before it is cooked. With this method of cooking, a sheet of metal with stands is heated up and oil is used to cook the food. A sufficient amount of oil is heated up and food is added. The food is then turned over a couple of times before it is dished out.

5. **Basting**

This method of cooking is usually associated with roasting. The juice or liquid that comes out of the meat being cooked is spooned over the roast frequently while it is being roasted. The outer part of the meat is moistened frequently during the cooking process with the juice that is being

spooned over. Usually, the extra juice from the cooked meat is added to a mixture to make the meat sauce.

6. Frying

Frying is a food processing method used to prepare both homemade and industrial products, which is widespread due to the sensory and organoleptic characteristics that make fried food more attractive to consumers (Simeon *et al.*, 2012). It is a very convenient method of cooking as it is fast and requires little food preparation (Fillion and Henry, 1998). Another reason for its great popularity is that frying generates very palatable foods due to the fat content, the crisp texture and rich flavours. It is an extremely complex process involving many factors some of which are dependent on the process itself and others on the food and the type of fat used (Fillion and Henry, 1998). It is mainly a dehydration process with three distinctive features compared to other processes;

- The high temperature of the oil (around 180°C) allows rapid heat transfer and a very short cooking time (only a few minutes).
- The temperature inside the product does not usually exceed 100°C (Califano and Calvelo, 1991).
- The process does not involve water hence there is no leaching out of water-soluble compounds, but instead some frying fat is absorbed in replacement or exchange of water lost by evaporation.

There are two main methods of frying, which are **shallow** and **deep** frying.

Shallow frying: In shallow frying, food is cooked in a frying pan with a little amount of oil or fat. The oil or fat is heated to the appropriate temperature and the food is put into the heated oil. The food is turned over a few minutes or is stirred around a couple of times before it is cooked and dished out.

Deep frying: This involves frying in a large amount of oil. The fat is usually heated to about 350°F (177°C) and the hot fat completely covers the food. Deep frying is primarily a dehydration process, which means that water and water-soluble substances are extracted from the product being deep fried and transferred to the cooking fat, and at the same time the product being deep fried absorbs surrounding fat (Choe and Min, 1997). If the product to be deep fried is placed in hot fat, the water on the surface evaporates and water moves from the inside of the product being

deep fried to the outer layer to compensate for the loss of water at the surface. During frying, the culinary fat or oil acts as a heat transfer medium and at the same time becomes an important ingredient of the fried food due to water loss as well as penetration of oil into the food (Ghita *et al.*, 2010). As the water released does not readily move from the hydrophilic surface of the food to the hydrophobic cooking fat, a thin layer of steam forms between the fat and the product being deep fried (Abiona *et al.*, 2011). The speed of the transfer depends more or less on the structure of the outer-crust. As soon as the transfer of the water ends, the temperature inside the food starts to rise above 100°C. At this point the typical deep-frying aroma, taste and the gold yellow colour begin to develop and the formation of acrylamide begins. The moisture released from the food forms a protective shield, preventing direct contact of oxygen to the fat surface. The quality of the product cooked depends on the following conditions: process (temperature, frying time, fryer type), frying oil (properties of the oil (chemical and physical) and additives, contaminants and the food (properties of food-chemical and physical, preparation, ingredients interchange with oil (Varela, 1988).

2.8 Properties of fried food

Fats and oils play important functional and sensory roles in food products (Mihaela *et al.*, 2010). They are responsible for carrying, enhancing and releasing the flavour of other ingredients, as well as for interacting with other ingredients to develop the texture and mouth-feel characteristics of fried foods (Giese, 1996). Fried foods have unique taste and sensory characteristics (Stier, 2000). One of the fundamental objectives of frying is to make food more acceptable, fat being a natural palatable agent *par excellence* (Mihaela *et al.*, 2010). When frying food, the hot frying fat that has penetrated into it, replaces part of the water it contains, making the food considerably more palatable (Varela *et al.*, 1998). This absorbed fat exerts a tenderizing effect on the crust, as well as a wetting effect on the food, thus contributes to the peculiarity of deep fried foods namely; favour, crispness and pleasant eating characteristics (Stevenson *et al.*, 1984). The typical fried flavour is mainly due to lipid degradation products originating from frying oils (Pokorny, 1999). Food fried at the optimum temperature and time have golden brown colour, are properly cooked, crispy and have optimal oil absorption while under-fried food at less

temperature or shorter frying time than the optimum have white or slightly brown colour at the edge and have ungelatinized or partially cooked starch at the center (Choe and Min, 1997).

2.9 Nutrient gains and losses from the fried food

2.9.1 Fat uptake

The amount of fat uptake during frying depends on a number of factors viz:

- The conditions of the frying process.
- The type and quality of frying fat.
- The characteristics of the food being fried.

The initial composition of the food (water and fat content) has a great effect on the fat uptake during frying. According to Markinson *et al.* (1987) plant foods, which initially have high water and low fat contents, absorbed more frying fat than animal foods. This can be explained by the intercellular spaces of animal tissues which are filled with fluid, while those of plant tissues are filled with air, which accounts for the greater capacity of plant foods to retain absorbed fat (Fillion and Henry, 1998). The report of Mai *et al.* (1978) on lipid changes of fresh-water fish fillets (trout and sucker) following different methods of cooking showed that the fillets from the trout was able to resist the absorption from frying oil, probably because of its high initial lipid content. This was confirmed by Gall *et al.* (1983) who studied fish species from the sea (red snapper and Spanish mackerel).

2.9.2 Changes in fatty acid composition

The report of Mai *et al.* (1978) on baked and pan-fried trout fillets, showed a slight loss in lipid which have no effect on relative distribution of the fatty acids. In contrary, there was a marked increase in fat content of fillets deep-fried in breading due to the absorption of frying oil by the breading. Although the changes in the fatty composition of the trout fillets were negligible, the fatty acid composition of the breading resembled that of the frying oil. Also, Sebedio *et al.* (1990) and Perez-Camino *et al.* (1991) reported similar fatty acid profile for the frying oil and French fries. Hence, foods with a high initial fat content have no change in the fatty acids composition because fat uptake was very limited or non-existent, however, when there is a fat uptake by the food (low initial fat content) the fatty acid composition of the absorbed fat reflects that of the frying oil. Invariably, a vegetable oil rich in mono and polyunsaturates will give a

food rich in these fatty acids, whereas foods fried in animal fats will be enriched in saturated fatty acids.

2.9.3. Proteins

Moreiras-Varela *et al.* (1984) reported that the protein digestibility of foods such as beef, pork, swordfish, meatballs and fish balls was not affected by frying without any additional ingredients. However, meatballs and fish balls containing flour showed a significant lower protein digestibility, although this decrease had no practical importance. When the metabolic utilization of pork, hake and meatballs with added carbohydrate was studied, except for meatballs with added carbohydrate, no alteration of the biological value and net protein utilization was found due to frying.

2.9.4. Carbohydrates (Resistant starch)

Thed and Phillips (1995) showed that, in comparison to raw samples, baking of frozen French fries had no effect on starch composition, while deep-frying significantly increased the percentage of resistant starch (on dry weight basis). This was attributed to the formation of amylose-lipid complexes (Asp and Bjorck, 1992). Although frying decreases the amount of digestible starch in potato, dietary fibre content is increased. Dietary fibre plays an important role in the prevention of diseases such as colonic cancer, cardiovascular, diverticulosis and diabetes, therefore, it is beneficial to consume more of them and fried potato products could help in this matter (Fillion and Henry, 1998).

2.9.5. Vitamins

The extent of vitamin destruction is dependent on the temperature and time of treatment. Deep frying has two main advantages over other cooking methods: (a) the temperature inside the food never exceeds 100°C as long as there is some liquid water left in it because frying time is usually very short (b) absence of leaching of water-soluble vitamins.

In view of this, some heat-sensitive vitamins (such as vitamin C and thiamine) are expected to be stable during frying than pressure cooking and boiling (Moreiras–Varela, 1988).

2.9.6. Water soluble vitamins in meat

The report of Al-Khalifa and Dawood (1993) when thiamine and riboflavin losses in chicken was compared after various method of cooking showed that in all cases, thiamine was more sensitive to heat than riboflavin. Higher losses of both vitamins occurred during roasting and

deep-frying while braising and microwave cooking resulted in lower losses. In addition, thiamine and riboflavin retention appeared to be higher in dark muscles, probably because of a lower water loss by draining. While Kimura *et al.* (1990) compared other methods of cooking of pork and found that the loss of thiamine was highest in boiling (70%), followed by steaming (40%), parching (35%) and frying (30%). This is explained by the water-soluble nature of the vitamin being leached out into the water. The study of Olds *et al.* (1993) on vitamin B₆ in raw and fried chicken showed that frying with batter resulted in a loss of total vitamin B₆ of about 6.5% with an overall retention of 93.5%, thus vitamins appear to be stable to deep-fat frying.

Thiamine is by far the most labile of the vitamins in meat. Its destruction depends on time and temperature. Microwave cooking resulted in lower loss while roasting leads to a higher loss. Loss of thiamine during frying depends on the type of meat: 70% loss in light muscles of chicken and 30% loss for pork (Fillion and Henry, 1998).

2.9.7. Lipid soluble vitamins

The report on the effect of processing on carotenoids content of Thai vegetables by Speek *et al.* (1988) showed that average losses of vitamin A activity were 14% for boiling, 24% for frying, 29% for fermenting, 44% for sun-drying and 60% for sun-drying followed by boiling. Some carotenoids were lost into the cooking water, but losses during frying were greater due to leaching into frying oil. Padmavati *et al.* (1992) noted that b-carotene losses were lower when processing/heating was kept to a minimum. They also reported that deep-frying resulted in twice the amount of loss that occurred during shallow frying. All vegetable oils used for frying contain vitamin E at a concentration between 15-49mg alpha-tocopherol equivalent/100g. Invariably, foods fried in vegetable oils are enriched with a substantial amount of vitamin E as reported by Holland *et al.* (1991). This represents an important intake considering that the recommended dietary allowance (RDA) is 10mg α TE/day (Food and Nutrition Board, Subcommittee of the Tenth Edition of the RDAs, 1989). However, a wide vitamin variation can be observed in relation to the quality of oil and the number of repeat frying the oil has undergone (Fillion and Henry, 1998).

2.9.8 Minerals

Gall *et al.* (1983) reported no changes in the mineral composition of fatty fish (Spanish mackerel) after baking or frying. In the case of low-fat fish (grouper and red snapper), they

found small losses of major minerals during baking (up to 20%) but losses after frying were very limited. Finglas and Faulka (1984) also compared losses of mineral in potatoes after boiling, baking and frying. They recorded losses only during boiling and it was assumed that the reduction in mineral content was the result of leaching into the cooking water. Mineral content was therefore very little affected by deep-frying in both potatoes and fish.

2.10 Losses from the frying oil

2.10.1 Unsaturated fatty acids

The investigation of Tyagi and Vasishtha (1996) on the changes in oil quality characteristics and fatty acid composition of soybean oil under frying conditions showed that changes in fatty acid profile during frying were basically among the unsaturated fatty acids, whereas the saturated fatty acids (myristic, palmitic and stearic) remained constant. Oleic acid (C18:1) showed gradual decrease from 26.7 to 20.7% after 70 hours, which amounted to a loss of about 21%. Linoleic acid (C18:2) deteriorated much faster after 70 hours, with 52% loss. Losses in linolenic acid (C18:3) were even higher and amounted to about 72%. During frying a progressive reduction in iodine value was observed, confirming the loss of unsaturated fatty acids. This reduction was attributed to the destruction of double bonds by oxidation, scission and polymerization.

2.10.2 Vitamin E

The report of Carlson and Tabacchi (1986) on deterioration and vitamin E loss of frying media showed that there was a significant increase in vitamin E loss in the frying oil during 4 days of commercial frying. However, there was no significant change in the vitamin E content of French fries, due to an increase in fat uptake of the fries which compensated the vitamin E reduction of the frying oil. In addition, a significant decrease of the vitamin C content of French fries occurred as the vitamin E content of the oil decreased during the 4 days of frying. These results were confirmed by Gordon and Kourimska (1995) who found that alpha-tocopherol was lost much faster than other tocopherols in rapeseed oil, with a reduction of 50% after 4-5 frying operations. The authors also showed that the use of a rosemary extract (0.1%) or ascorbyl palmitate (0.02%) reduced significantly the rate of loss of tocopherols. The stabilizing effect of the rosemary extract was slightly greater than the ascorbyl palmitate at the concentration used.

2.10.3 Beta-carotene

The study of Manorama and Rukmini (1991) on the effect of processing on beta-carotene retention in crude palm oil showed that beta-carotenes were depleted after the first frying, and the second and further consecutive frying resulted in a sharper fall in carotenes. This was due to the presence of some co-oxidation products of carotene in heated palm oil as indentified by Wong (1977). This indicates that the loss of beta-carotene during repeated frying was due, at least in part to oxidation (Fillion and Henry, 1998). Loss of all-trans beta-carotene was almost complete after 20 minutes in red palm oil heated to 170°C up to 30 minutes. However, with the addition of curry or chaya leaves (10%) to the oil, some all-trans beta-carotene was left after 30 minutes, and it was suggested that this protective effect against oxidation was due to antioxidants (vitamin C, carotenoids and flavonoids) from the leaves (Lietz *et al.*,1998). This report also compliments the findings of Gordon and Kourimska (1995). Carlson and Tabacchi (1986) also reported that antioxidants added to the frying medium provide a good protection against oxidation of other nutritionally important anti-oxidants already present in the oil or in the fried food.

From researches, it was assumed that frying process does not appear to have a major impact on the nutritive value of foods. The short frying time combined with an inner temperature not exceeding 100° C leads to good nutrient retention. Frying has almost the same or even less effect on nutrient losses than other cooking methods such as boiling or baking. For instance, frying has very little impact on the protein utilization or mineral content of fried food. Heat labile vitamins such as vitamin C and thiamine are well retained after frying, moreover, frying can increase the nutritive value of foods since many frying oils are rich in vitamin E. All these indicate that fried foods contribute to the macro and micro nutrient intake. They are palatable due to the fat content, the formation of a crust and development of unique flavours (Fillion and Henry, 1998).

2.11 Types of meat

2.11.1 Goat meat (chevon)

Goat population as described by Naudé and Hofmeyr (1981) comprises of four types. They are fibre goats (e.g. Angora, Cashmere), dairy goats (e.g. Saanen, Toggenburg, and Nubian), meat goats (e.g. Boer) and feral goats. The goat is an important meat animal in Africa, Asia and the

Far East and is now emerging as an alternative and attractive source of meat in other parts of the world (Dhanda *et al.*, 2003).

Chevon is the most popular meat product in the world and is often served in specialty dishes centered on festival or holiday events (Sande *et al.*, 2005). Goats were initially produced for fiber and milk, with chevon as a by-product. With the decline in the importance of fiber, most producers diverted attention to raising meat goats (Sande *et al.*, 2005). More producers have come into the industry as well and the increase has stemmed mainly from the rise in niche-market populations with cultural preferences for chevon.

Meat-goat production is also growing because goats are efficient converters of low-quality forages into quality meat, milk and hide products suitable for many specialty markets (Nye and Moore, 2002). The meat goat is also popular in situations where resources are limited. Goats are particularly attractive to small-scale producers because the small animals do not require large tracts of land and are easier to handle than larger livestock (Tadesse, 2004). Chevon offers consumers tasty, lower-fat meat than beef or pork (Getz, 1998). The fat content is lower by 47 and 54% than beef and mutton respectively (Gelaye and Amoah, 1991). Addrizo (1999) found that roast chevon had lower calories, fat and saturated fat but higher protein and iron than roast beef, pork and lamb. It was however, nearly comparable to chicken. Generally, chevon is unique in flavour, palatability and, in comparison to other red meats, it is a better health product. Besides the chemical composition of goat meat, the sensory characteristics are also fundamental because the degree of acceptability by the consumer depends mainly on the appearance, odour, flavour and texture of the meat (Madruga *et al.*, 2005). However, some authors claim that goat meat is disliked due to its distinct odour (due to presence of musk glands) and taste, typical of animals slaughtered older (Intarapichet *et al.*, 1994). Despite the low lipid content in this meat compared to meat from other ruminants, goat meat has a high proportion of unsaturated fatty acids in addition to being a source of conjugated linoleic acid (Webb *et al.*, 2005). These compounds have beneficial effects on human health as anti-inflammatory, anti-thrombotic and atherosclerotic preventatives (Givens *et al.*, 2006).

2.11.2 Cattle meat (beef)

Beef is the culinary name for meat from bovines, especially domestic cattle. Beef can be harvested from cows, bulls, heifers or steers. Cows were first domesticated for beef in the

regions of Greece and Turkey about 4000 years ago. Beef is the third most widely consumed meat in the world, accounting for about 25% of meat production worldwide, after pork and poultry at 38% and 30% respectively (Raloff, 2003). Beef is an excellent source of complete protein and minerals such as zinc, selenium, phosphorus and iron, and B vitamins. Beef is a red meat, which is the most significant dietary source of carnitine and, like any other meat (pork, fish, veal, lamb etc.), is a source of creatine (WHF, 2004).

Beef are usually characterized by low polyunsaturated to saturated fatty acids ratio due to the massive hydrogenating action performed by rumen microorganism on dietary fatty acids (Braghieri *et al.*, 2005). Beef is available in a wide variety of breeds throughout the year. Bovine meats present an interesting nutritional qualities being an important source of macro and micro nutrients for man (Ortigue-Marty *et al.*, 2006). Lean beef is a very good source of protein and vitamin B₁₂ and a good source of Selenium (Elizabeth, 1994) which was also confirmed by Ortigue-Marty *et al.* (2006). It was confirmed that the daily consumption of 100g of cooked meat beef in particular would supply an average of 57% of the recommended intake of Vit B₁₂ at 2.4µg/day.

The nutrient contents of beef were reported by Hedrick *et al.* (1994) as 65 – 80% moisture, 18.5% protein, 3.0% fat, 1.5 % non-protein nitrogenous substance, 1.5% carbohydrate and 1% ash. Kembu and Okubanjo (2002) recorded a moisture content of 69.98%, protein 21.89%, fat 5.99% and ash content of 1.20% for raw minced beef patties which is a little far from values reported by Walshe *et al.* (2006). This variation in values might be due to various factors of which breeds is one of the most important as stated by Okubanjo (1982) that lean characteristics is affected/associated with breed, sex and age of the animal. This was also affirmed by Okubanjo *et al.* (2003) especially on the influence of three breeds of cattle (Bunaji, Gudali and Keteku) on the lean characteristics. According to them a cooked beef of these breeds will have a colour (%) of 5.66, 5.34, 5.66; shear force value (Kg) 4.60, 4.93, 4.04; tenderness/texture (%) of 5.60, 7.00, 3.00 and cooking loss (%) of 24.00, 8.70, 16.97 for Bunaji, Gudali and Keteku breeds respectively.

2.11.3 Pig meat (pork)

Pigs are reared for the production of pork. They are highly prolific, producing up to 10-12 piglets each time of farrowing. Their growth is also very fast. Pigs have the capacity to convert inedible

feeds and garbage into nutritious and costly meat. The specific is largely maintained by the economically weaker sections of the society.

However, in the last three decades, breeding with the two imported breeds (Yorkshire and Landrace) have been widely used for crossbreeding in India and the breeding programme has shown very good result around bacon factories. Further breeding of desi pigs with these crossbreds has brought about a significant improvement in the overall stock within the country. Pig population has maintained an encouraging growth during the last over one decade. Almost every rural household rears them and thus pig farming is playing a vital role in improving the socio-economic conditions of the rural population.

Pigs should be slaughtered at 6 to 7 months of age. An ideal slaughter weight is approximately 50 kg for desi pigs and 60-70 kg for crossbred pigs. Dressing percentage varies from 65-70% in case of desi pigs and 70 to 75% of the live weight in case of crossbred pigs. The yield is more from pigs as compared to other species due to the presence of skin on the carcass. Almost 98% of pig population is slaughtered every year which contributes to about 12.5% of the total meat production. Pork is grey pink in colour with very soft consistency. It emanates a urine like colour. There is a huge subcutaneous deposition of fat which is white in colour and soft greasy in consistency.

2.12 Meat Quality Study

Meat quality is a generic term used to describe properties and perceptions of meat. It includes attributes such as carcass composition and conformation, the eating quality of the meat, health issues associated with meat and production-related issues including animal welfare and environmental impact (Maltin *et al.*, 2003). These factors combine to give an overall assessment of meat quality by the ultimate arbiter, the consumer. The critical point of appraisal of meat quality occurs when the consumer eats the product, and it is this outcome, together with views of colour, healthiness and price, that determine the decision to re-purchase (Boleman *et al.*, 1997).

Meat quality evaluation is important in improving meat production (Barbera and Tassone, 2006). For instance in the processing of meat, yield is the main quality parameter as it determines the amount of available product for sale and is therefore of direct economic importance (Aaslyng, 2002). However, consumer evaluation of eating quality is the major determinant of meat quality,

with tenderness, juiciness and flavour of meat being the most important elements (Martin *et al.*, 2003). However, the main source of consumer complaint and the primary cause of failure to re-purchase is the variability in eating quality, especially tenderness (Bindon and Jones, 2001). Some of the qualities assessed in meat include:

2.12.1. Cooking loss

Cooking is a process of heating meat at sufficiently high temperatures that denature proteins and make it less tough and easy to consume (Garcia- Segovia *et al.*, 2006). Cooking loss, which is one of the meat quality parameters, refers to the reduction in weight of meat during the cooking process (Vasanthi *et al.*, 2006). Among different methods to evaluate cooking effects on meat, the cooking loss measurement represents the most rapid and important to estimate some correlated quality characteristics such as juiciness and evaluate some economic aspects (Bertram *et al.*, 2004). Most of the water in the living muscle is held within the myofibrils and any large changes in the distribution of water within the meat structure originate from changes in this spacing. Cooking induces structural changes which decrease the water holding capacity of the meat. Cooking temperatures have been reported to cause drastic changes in beef, such as shrinkage of meat protein network and protein coagulation (Barbera and Tassone, 2006). For instance, beef cooked swiftly to a given internal temperature has a low cooking loss and is juicier than beef cooked at the same temperature slowly (Jama *et al.*, 2008). This is because a high heat ($\geq 70^{\circ}\text{C}$) rapidly coagulates the proteins on the beef surface and so rapidly forming a layer that protects much cooking losses by evaporation and drip (Lawrie, 1998). Contrary, shrinkage of protein networks increases at cooking temperature below 60°C . This occurs because of the long duration to be taken to achieve the required internal temperature. This duration also retards the rapid formation of the surface layer for protection against moisture losses (Jama *et al.*, 2008).

As observed by Palka and Daun (1999), increasing the temperature to 100°C causes the meat structure to become more compact due to a significant decrease in fiber diameter. During heating at varying temperatures ($37\text{--}75^{\circ}\text{C}$), meat proteins denature and cause structural changes such as transversal and longitudinal shrinkage of muscle fibers and connective tissue shrinkage (Offer, 1984). An increase in cooking loss has a large financial impact in beef industry. For example, beef products such as sausages have significant amounts of high protein quality and are good sources of several essential minerals, including iron and zinc as well as B vitamins. The

increased loss of such nutrients deteriorates the beef nutritional quality and lowers its purchase (Pearson and Gillett, 1988). The cooking loss levels (23.2%; 25.1%), (23.5%; 23.4%), (24.9%; 23.9%) in steaks aged for 2 days and 21 days for Nguni, Bonsmara and Angus breeds of cattle respectively in the study carried out by Jama *et al.* (2008) were slightly higher than those reported by Jeremiah and Gibson (2003) which averaged 22.5% but lower than those reported by Razminowicz *et al.* (2006) in pasture-fed steers which averaged 30%. The differences in cooking losses may be attributed to several factors such as differences in ageing, cooking method applied, cooking temperatures, duration of cooking temperatures, pH and marbling (Yu *et al.*, 2005).

2.12.2. Thermal shortening

This refers to the degree of shrinkage observed in a cooked meat, which is very important to the consumers (Barbera and Tassone, 2006). It is measured as a decrease in fiber diameter or sarcomere length (Tornberg, 2005). McDonald and Sun (2001) measured the shrinkage of cooked beef using sliding vernier callipers before and after the cooking and cooling. A very recent measurement of shrinkage has been proposed by Du and Sun (2005) for automatic shrinkage evaluation of pork ham after cooking and cooling.

2.12.3. Water Holding Capacity (WHC)

Muscle contains approximately 75% water. The other main components include protein (approximately 20%), lipids or fat (approximately 5%), carbohydrates (approximately 1%) and vitamins and minerals (often analyzed as ash, approximately 1%). The majority of water in muscle is held within the structure of the muscle itself. Once muscle is harvested the amount of water in meat can change depending on numerous factors related to the tissue itself and how the product is handled.

Water-holding capacity of meat is defined as the ability of the postmortem muscle (meat) to retain water even though external pressures (e.g. gravity, heating, centrifugation, pressing, etc) are applied to it (Honikel, 1998). The WHC of meat products is a very important quality attributes which has an influence on product yield, which in turn has economic implications, but is also important in terms of eating quality (Adam *et al.*, 2010).

2.12.4. Water Activity (a_w)

Water in food products functions as a reaction medium, reactant, oxidizer, and structural component. Water is the most important factor in controlling the rate of deterioration of a food.

However, knowledge of the moisture content of a food is not sufficient to predict its stability. It is the *availability* of water for microbial, enzymatic or chemical activity that determines the shelf life of foods. This water availability is referred to and measured as **water activity** (a_w). Water activity (a_w) affects food chemistry and can be controlled by removal (dehydration or drying) or by chemically binding the water, reducing its activity. Water activity is measured on a scale of 0 to 1 where 0 indicates no water and 1 indicates all water. Rates of degradation due to microbial action increase with higher water activities. Many common bacteria proliferate at $a_w > 0.9$, some yeasts can develop at a_w as low as 0.6 to 0.7 requiring either additional lowering of a_w or addition of antimicrobial agents. Microbial activity can be reduced by drying foods, thereby lowering the moisture content and a_w . Food spoilage micro-organisms in general are inhibited in food where the water activity is below 0.6. However, if the pH of the food is less than 4.6, micro-organisms are inhibited when the water activity is below 0.85 (Linko *et al.*, 1985; Pomeranz, 1991).

2.12.5. Sensory evaluation of meat products

Sensory or organoleptic qualities of meat are determined by sensory characteristics relating to colour, texture, aroma, flavour and juiciness and these are influenced by a number of factors including pre-slaughter handling, muscle composition, post slaughter biochemical reactions and technological factors (Nasir *et al.*, 2011).

The sensory quality of the processed product has an indirect economic importance as it might influence the amount of sold product, especially how often a consumer buys the same product again (Aaslyng, 2002). All eating quality attributes are influenced by factors within the production system, including feeding strategies, gender and slaughter weight and also by processing methods e.g. ageing (Wood *et al.*, 1995). Bejerholm and Aaslyng (2003) reported that meat (*Longissimus dorsi*) from pigs with a high warm carcass weight (>90 kg) was more tender than meat from the pigs with low warm carcass weight (<65 kg), but the weight did not influence odour and flavour attributes. On the contrary, Candek-Potokar *et al.* (1998) found that an increase in body weight at slaughter (from 100 kg to 130 kg) resulted in lower tenderness of *L. dorsi*. However, these pigs were also older. Age variations between two weight classes could probably explain some of the contradictory conclusions obtained in the reported studies, as meat from older animals is tougher than meat from younger animals due to a higher degree of collagen cross-linking (Ellis and McKeith, 1995), and the various muscles from the pig differ in collagen

content (Bailey and Light, 1989). Although the majority of the reported investigations have been conducted on *L. dorsi*, in relation to meat quality attributes, slaughter weight is almost exclusively correlated to texture (Meinert *et al.*, 2008). It is known that the sensory properties (smell, taste, colour, juiciness, texture and tenderness) represent the principal factors able to condition drastically the choices of the consumers at the moment of purchase, therefore, they have a role of primary importance regarding the qualification of the product (Porcu *et al.*, 2007). The organoleptic test showed that the taste of the meat (which invariably determine consumers acceptability is a function of processing, preservation and the type of meat (Linda *et al.*, 1990). Flavour, appearance, tenderness and juiciness are very important attributes with regard to eating quality of pork (Wood *et al.*, 1995). Consumer study by Aaslyng *et al.* (2007) revealed that consumers prefer tender pork with an intense fried flavour and that both attributes varied with raw meat quality and cooking method. Some of the sensory qualities include:

A. Flavour and Aroma

Flavour is experienced during mastication when volatiles are released in the oral cavity and aroma is perceived by the olfactory system. Flavour is generated from reactions of various flavour precursors including reducing monosaccharides and inosine monophosphate (IMP) during heating (Mottram and Madruga, 1994). Flavour is mainly generated during the heating process and the Maillard reactions involving reducing carbohydrates and amino acids are one of the most important routes to flavour formation (Mottram, 1991). Reports have shown that cooking process in relation to flavour formation is significant and temperature is of major importance. For instance, Wood *et al.* (1995) showed that pork flavour increased as the core temperature of grilled steaks increased from 65 °C to 80 °C, while both juiciness and tenderness simultaneously decreased.

B. Tenderness

Tenderness is defined by the ease of mastication, which involves initial penetration by the teeth, the breakdown of meat into fragments and the amount of residue remaining after chewing (Lawrie, 1998). Meat tenderness is considered the most important palatability attribute of meat (Cross *et al.*, 1986) and it is a critical eating quality which determines whether consumers are repeated buyers (Koochmaraie *et al.*, 1989). Variations in tenderness affect the decision to repurchase (Maltin *et al.*, 2003).

Tenderness is an integrated textural property composed of mechanical, particulate and chemical components. The mechanical characteristics include hardness, cohesiveness, elasticity, grittiness and fibrousness while the chemical characteristics of meat include juiciness and oiliness (Brewer and Novakofski, 2008). Tenderness being a complex trait depends on sarcomere length, muscle/connective tissue proteins and proteolytic degradation and these might have accounted for most variation in tenderness of meat (Koochmaraie *et al.*, 2002). Tenderness has also been shown to depend positively upon intramuscular fat (Aaslyng and Støier, 2004) and ageing (Wheeler and Koochmaraie, 1994), and negatively on the amount of connective tissue (Honikel, 1992).

C. Texture

Texture plays a crucial role in determining food quality, its acceptance by consumers and eventually their preferences (Guinard and Mazzuchelli, 1996; Szczesniak, 2002) and is one of the most important sensorial attributes in the process, selection and consumption of foods (Szczesniak, 2002). Bourne (1975) defined food texture as 'the response of the tactile senses to physical stimuli that result from contact between some part of the body and the food'. Other researchers have also included a contribution from the other senses, such as vision, hearing, olfaction, and kinesthesia in their definition (Szczesniak, 1990).

D. Juiciness

The two sensory descriptive words for juiciness, in cooked meat, are initial and sustained juiciness (Lyon and Lyon, 1989). Initial juiciness is the amount of fluid released by the cut surface of meat, during compression between the forefinger and thumb (AMSA, 1995). Initial juiciness of meat is positively correlated with the water holding capacity of meat, which is influenced by the muscle's ultimate pH at post mortem (Offer and Trinick, 1983). Sustained juiciness is described as the perceived juiciness after a few seconds of mastication, due to the presence of intramuscular fat stimulating saliva secretion (Lawrie, 1998).

Juiciness is the feeling of moisture in the mouth during chewing. It is a dynamic attribute changing during the chewing process (Aaslyng, 2002). The content of intramuscular fat is positively correlated to juiciness (Cummings *et al.*, 1999; Brewer *et al.*, 2001). Juiciness is an important factor in sensory evaluation as it facilitates the chewing process as well as brings the flavour component in contact with the taste buds (Aaslyng *et al.*, 2002). The juiciness of meat

depends on the raw meat quality and the cooking procedure (Aaslyng *et al.*, 2002). Other factors like concentration of glycogen could also influence the juiciness as an increased concentration of glycogen have been reported to increase the juiciness in beef with a normal pH between 5.5 and 5.75 (Immonen *et al.*, 2000).

2.13 Quality Assessment of meat products

The quality of meat products could be assessed based on certain intrinsic and extrinsic characteristics. It is nevertheless better reflected by consumers' perception, which although different from the real and objective quality, it determines the purchase of the product. Factors influencing demand for product quality are found to be linked to the social, economic and cultural context and other factors affecting diet habits. The quality of meat products could be assessed on the basis of a number of attributes and this includes evaluation and assessment of oxidative and flavour deterioration and how microbiologically safe the product is.

2.13.1. Lipid oxidation

Lipid oxidation is a main deteriorative reaction that occurs during processing, distribution, storage, and final preparation of foods. These oxidative reactions result in the destruction of fat soluble vitamins and essential fatty acids, as well as undesirable changes in color, flavour, aroma, and consistency of the food, making them unfit for consumption (Gray *et al.*, 1996; Luzia and Jorge, 2009). It can also be referred to as the oxidative processes that lead to the degradation of lipids and proteins and are one of the primary mechanisms of quality deterioration and limiting the shelf life in meat and meat products (Pizzalle *et al.*, 2002; Lui *et al.*, 2010). One simple way by which food can develop an off-flavour is by coming in contact with the source of off-flavour during processing or during storage. The lipid component of the food or the edible fat acts as a very good sink into which the volatile off-flavours may dissolve. The problem of oxidative deterioration is of greatest economic importance in the production of lipid-containing foods because it decreases the nutritional quality and safety by the formation of secondary reaction products (Frankel, 1987).

One of the off-flavours that develops during processes is known as rancidity, which is the term associated with the development of off-flavours in foods and is defined as the subjective organoleptic appraisal of the off-flavour quality of food. It is subjective because the ability to

perceive an off-flavour varies from person to person. Rancidity can be divided into two broad groups, which are;

A. Hydrolytic rancidity: This occurs as a result of the formation of free fatty acids and soaps (salt of free fatty acids) and is caused by either the reaction of lipid and water in the presence of a catalyst or by the action of lipase enzymes. Water and fat can exist in contact with one another for months at a time. The rate of reaction between water and fat can become significant if there is a suitable catalyst (lipase enzymes and acidic catalysts) present and the temperature is raised. When a food is contaminated by bacteria and is subsequently heated, a hydrolytic rancidity condition occurs. In these situations, the triglycerides in the food are hydrolysed, first to diglycerides, then to monoglycerides and finally to fatty acids.

B. Oxidative rancidity: The oxidation of lipids leading to rancidity is one of the most important changes during food storage (Rosmini *et al.*, 1996) and is a common and frequently undesirable chemical change that may impact flavour, aroma, and nutritional quality and in some cases even the texture of a product. The chemicals produced from oxidation of lipids are responsible for rancid flavours and aromas, although not all flavours derived from oxidation of lipids are undesirable, that is, give rise to unpleasant off- flavours. For instance, aldehydes with unsaturation at the 2nd position is described as sweet and pungent at one shorter chain length and as sweet, fatty and green at longer chain lengths while aldehydes with conjugated unsaturation at the 2nd and 4th positions are noted as sweet or oily and 2, 4 dienals with chain lengths from C₈ to C₁₂ are reported to make a positive contribution to the flavour of chocolate (Dick Hamilton, 2005).

Lipid oxidation occurs from more complex lipid oxidation processes. The processes are generally considered to occur in three phases, which are initiation or induction, propagation and termination phases and in complex systems, the products of each of these phases will increase and decrease over time making it difficult to quantitatively measure lipid oxidation.

The Initiation or Induction phase involves molecular oxygen combining with unsaturated fatty acids to produce hydroperoxides and free radicals both of which are very reactive. For this phase to occur at any meaningful rate, some types of oxidative initiators must be present such as chemical oxidizers, transition metals (iron or copper) or enzymes (lipoxygenases). Also, heat and light increase the rate of this phase and other phases of lipid oxidation. In this early stage,

process of lipid oxidation, peroxides and hydroperoxides are the predominant reaction products, which continue to increase until; (a) storage conditions change, (b) one or more initiators is depleted, (c) available oxygen is consumed, or (d) the lipid substrate is exhausted. The reactive products of this initiation phase will in turn react with additional lipid molecules to form other reactive chemical species. The propagation of further oxidation by lipid oxidation products give rise to the term 'auto oxidation' that is often used to describe the process. In the final termination phase of lipid oxidation, relatively unreactive compounds are formed. These include hydrocarbons, aldehydes and ketones, most of which are volatile. Consequent upon their volatility, their concentration of the compounds in the product may also begin to decrease over time. The rate of decrease varies with storage conditions, packaging and fat content.

Some of the factors that can influence the rate of lipid oxidation in a product include:

- The initial quality of the fat or oil used for manufacturing the product.
- Conditions used to manufacture the product.
- Storage conditions (heat, light, packaging).
- Surface area exposed to atmospheric oxygen.
- Presence of transition metals.
- Concentration of active lipoxygenases.
- Application of appropriate of synthetic or natural preservatives.
- Presence of chemical oxidizers.

2.14 Factors affecting lipid oxidation in meat and meat products

Lipid oxidation starts immediately after slaughtering and during post slaughtering events. The rate and extent of lipid oxidation in muscle tissues appears to be dependent on degree of muscle tissues damages during pre-slaughtering events such as stress and physical damage and post-slaughtering events such as early post-mortem pH, carcass temperature, shortening and tenderization technique such as electrical stimulation (Morrissey *et al.*, 1998). Furthermore, various processing factors can influence the rate of lipid oxidation in meat and meat products. They include composition of raw meat, aging time, cooking or heating, size reduction processes such as grinding, flaking and emulsification, deboning, especially mechanical deboning,

additives such as salt, nitrite, spices and antioxidants, temperature abuse during handling and distribution, oxygen availability and prolonged storage (Kanner, 1994).

Phospholipids play a critical role in the development of lipid peroxidation in raw and cooked meat. As reported by Pikul *et al.* (1984) phospholipid fraction contributed about 90% of the malonaldehyde measured in total fat from chicken meat. It was also reported that the polyunsaturated (PUFA) content of phospholipids was related to the development of rancidity (Igene *et al.*, 1980). Report of the studies of Kim *et al.* (2002) showed that beef have a higher susceptibility to lipid peroxidation than pork and turkey breast muscle.

Oxygen availability is also one of the most important factors for the development of lipid peroxidation in raw and cooked meat. Any process causing disruption of the membranes such as size reducing processes (grinding, flaking, mincing etc), deboning and cooking result in exposure of phospholipids to oxygen and therefore accelerates development of oxidative rancidity (Ladikos and Lougovois, 1990). The level of oxygen content in modified atmosphere and vacuum packaged raw and cooked beef was proportional to that of lipid peroxidation (O'Grady *et al.*, 2000; Smiddy *et al.*, 2002).

To delay lipid oxidation, synthetic antioxidants have been applied extensively in food products (Ahmad, 1996). However, due to consumer preferences for natural ingredients over synthetic compounds (Ahn *et al.*, 2002) there is a demand for discovery of new plant extracts that can reduce lipid oxidation in lipid-containing food products. Many natural plant extracts contain primarily phenolic compounds which are potent antioxidants (Wong *et al.*, 1995). Phenols are one of the most important groups of natural antioxidants and they occur only in material plant origin and they are known to easily protect oxidizable constituents of food from oxidation. Especially worthy of note among such plants are spices and herbs, which have been used as additives to enhance the sensory features of food (Wang *et al.*, 1996).

For instance, grape seed and green tea extracts contain large amounts of antioxidant compounds (Fadhel and Amran, 2002). Rababah *et al.* (2004) investigated antioxidant activities of some plant extracts and found that grape seed and green tea extracts showed the highest antioxidant activities. Natural antioxidants such as sesamol, quercetin, rutin and rosemary have been shown to reduce thiobarbituric acid reactive substances (TBARS) value (index used to measure extent of lipid oxidation) in irradiated raw meat during storage (Chen *et al.*, 1999). Ahn *et al.* (2002)

also reported that selected natural antioxidants reduced development of warmed-over flavour and TBARS values in cooked ground beef. Studies also carried out by Devatkal and Mendiratta (2001) showed that TBARS increases during storage of different meat and meat products.

2.15 Microbiology Assessment of Meat

Microbial contamination of meat leads to rapid spoilage and thus seriously affect the consumer acceptance and economic loss (Fakhruddin *et al.*, 2003). During the process and storage, the meat is more prone to pigment and lipid oxidation, thus decreasing organoleptic qualities of the meat products and posing a major problem in the storing of convenient meat products (Pearson *et al.*, 1983; Verma and Sahoo, 2000). The bacterial safety and rate of spoilage depends upon the numbers and types of micro-organisms initially present, the rate of growth of those microorganisms, the conditions of storage (temperature and gaseous atmosphere) and characteristics (pH, water activity a_w) of the meat (James and James, 2002).

2.16. Spoilage Organisms

Chemical reactions that cause offensive sensory changes in foods are mediated by a variety of microbes that use food as a carbon and energy source. These organisms include prokaryotes (bacteria), single-celled organisms lacking defined nuclei and other organelles, and eukaryotes, single-celled (yeasts) and multicellular (molds) organisms with nuclei and other organelles. Some microbes are commonly found in many types of spoiled foods while others are more selective in the foods they consume. Multiple species are often identified in a single spoiled food item but there may be one species (a specific spoilage organism, SSO) primarily responsible for production of the compounds, causing off-odours and flavours (Ellin, 2007). Within a spoiling food, there is often a succession of different populations that rise and fall as different nutrients become available or are exhausted. Some microbes such as lactic acid bacteria and molds secrete compounds that inhibit competitors (Gram *et al.*, 2002).

2.17. Types of Micro-organisms

2.17.1 Yeast

Yeasts are a subset of a large group of organisms called fungi that also includes molds and mushrooms. They are generally single-celled organisms similar in many ways to bacteria except

that they are larger. The reproduction of yeast is by budding process that is adapted for life in specialized, usually liquid environments and, unlike some molds and mushrooms, do not produce toxic secondary metabolites. Yeasts can grow with or without oxygen (facultative) and are well known for their beneficial fermentations that produce bread and alcoholic drinks. They often colonize foods with a high sugar or salt content and contribute to spoilage of maple syrup, pickles, and sauerkraut. Fruits and juices with a low pH are another target, and there are some yeasts that grow on the surfaces of meat and cheese. For instance, 'brown spot' sometimes seen on vacuum-packaged meat six-eight weeks old is caused by yeast (Smits and Brul, 2005; Kurtzman, 2006).

2.17.2. Moulds

Moulds are filamentous fungi that do not produce large fruiting bodies like mushrooms. Its growth on foods is usually identified by the whisker-like or 'fuzzy' appearance of the growth mass. Moulds grow from spore, but they can also grow if any part of the growth mass is transferred to a suitable surface. Molds are very important for recycling dead plant and animal remains in nature but also attack a wide variety of foods and other materials useful to humans. They are well adapted for growth on and through solid substrates, generally produce airborne spores, and require oxygen for their metabolic processes. Most molds grow at a pH range of 3 to 8 and some can grow at very low water activity levels (0.7–0.8) on dried foods. Spores can tolerate harsh environmental conditions but most are sensitive to heat treatment. An exception is *Byssochlamys*, whose spores have a D value of 1–12 minutes at 90°C. Different mold species have different optimal growth temperatures, with some able to grow in refrigerators. They have a diverse secondary metabolism producing a number of toxic and carcinogenic mycotoxins. Some spoilage molds are toxigenic while others are not (Pitt and Hocking, 1997).

2.17.3 Bacteria

These are single-celled organisms. The reproduction of bacteria is by cell division. Given favourable conditions, the generation time (the time between consecutive divisions) for some species of bacterial is less than 20 minutes, thus resulting in a rapid increase in numbers, that is, a rapid growth rate. Under favourable conditions, there can be more than a hundred-fold increase in numbers in just two hours. Bacterial growth is controlled by creating conditions unfavourable for rapid reproduction. **Spore-forming bacteria** are usually associated with spoilage of heat-

treated foods because their spores can survive high processing temperatures. Bacteria have an overriding importance to the meat industry and the factors which affect and control growth of bacteria similarly affect the growth of other types of microorganisms.

2.18 The Growth of Bacteria

The growth cycle of bacteria can be divided into four distinct phases (Figure 2):

- (a) Lag phase: This is a period of adjustment to a new environment. For instance, when a fresh meat becomes contaminated for the first time by a number of bacterial cells, the cells acclimate to the new atmosphere and nutrients available to them and repair any damage they may have suffered.
- (b) Growth phase: Once adjusted, the bacteria commence active multiplication, growing in number by regular cell division.
- (c) Stationary phase: The availability of growth substrates (e.g. nutrients and in some cases oxygen) and the reduction in pH, occurring as a result of acids produced during growth limit the ability to grow.
- (d) Death phase: At this phase, the rate at which cells are dying exceeds their growth rate causing a net reduction in the number of viable cells.

The most important parts of the growth curve in the meat industry are the lag and growth phases.

The stationary phase only occurs when bacterial numbers reach a figure of over one hundred

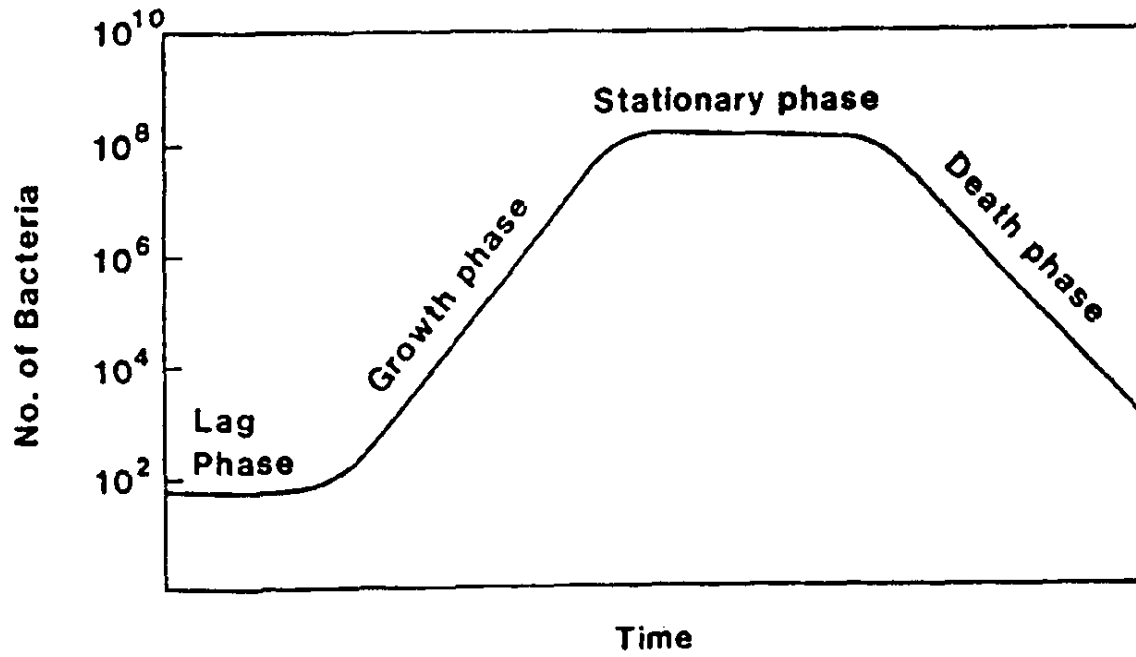


Figure 2. The bacterial growth curve

Source: www.google.bacterialgrowth.curve. Accessed 20/9/2012

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million per square centimeters ($10^8/\text{cm}^2$) which is more than ten times the number required to cause spoilage. Spoilage first becomes apparent under normal conditions when bacterial numbers reach around ten million per square centimeters ($10^7/\text{cm}^2$) at which time off-odours can first be detected while slime appears at near $10^9/\text{cm}^2$.

2.19 Factors affecting bacterial growth rate and spoilage

The rate at which bacteria reproduce (growth rate) is governed by their environment. Other factors that influence the growth rate of bacteria include:

- Nutrients
- Temperature
- Type of bacteria
- Moisture
- Gaseous atmosphere
- pH

All these coupled with the presence of growth limiting chemicals affect the growth rate. The environment, as defined by these factors, determines the shape of the growth curve for bacteria and the ultimate bacterial numbers obtained before growth is limited.

2.19.1 Nutrients

Meat is rich in nutrients, and the availability of these is dependent on the exposed surface area and degree of rupture of the meat's structure. Minced meat will have greater nutrient availability than sliced meat which will be greater than whole primal and carcasses.

2.19.2 Temperature

This is the most important factor affecting the growth of bacteria and due to this bacteria are roughly classified according to the temperature at which they grow.

Most bacteria fall into the group called **mesophiles**, which grow best between 20-45°C, bacteria which grow at lower temperatures are called **psychrophiles** and grow best between temperature -5 to 20°C (e.g. chillers grow best at 0°C), while bacteria which grow at higher temperatures are called **thermophiles** and these organisms grow well above 45 °C.

Optimum growth for most bacteria occurs at temperature between 20 and 40°C. Invariably, the nearer the storage temperature of the meat is to the optimum growth temperature, the faster it

will spoil. Firstly, an increase in temperature allows bacteria to adjust to their environment more rapidly, thus shortening the lag phase (Figure 2). Secondly, when the growth rate of the bacteria is increased, it reduces the time taken for numbers to reach spoilage level. The product stored at lower temperature will have a greater shelf life than those stored at the higher temperature despite the fact that both started with the same initial number of bacteria.

2.19.3 Types of bacteria

Different species of bacteria have different optimum temperatures for growth and different growth rate responses to temperature, pH, salt, water activity and gaseous atmosphere. For instance, pseudomonas bacteria grow very slowly at 0°C, but sufficiently faster at 2°C to halve the shelf life of meat, while salmonella will only grow at temperatures above 7°C (Figure 3).

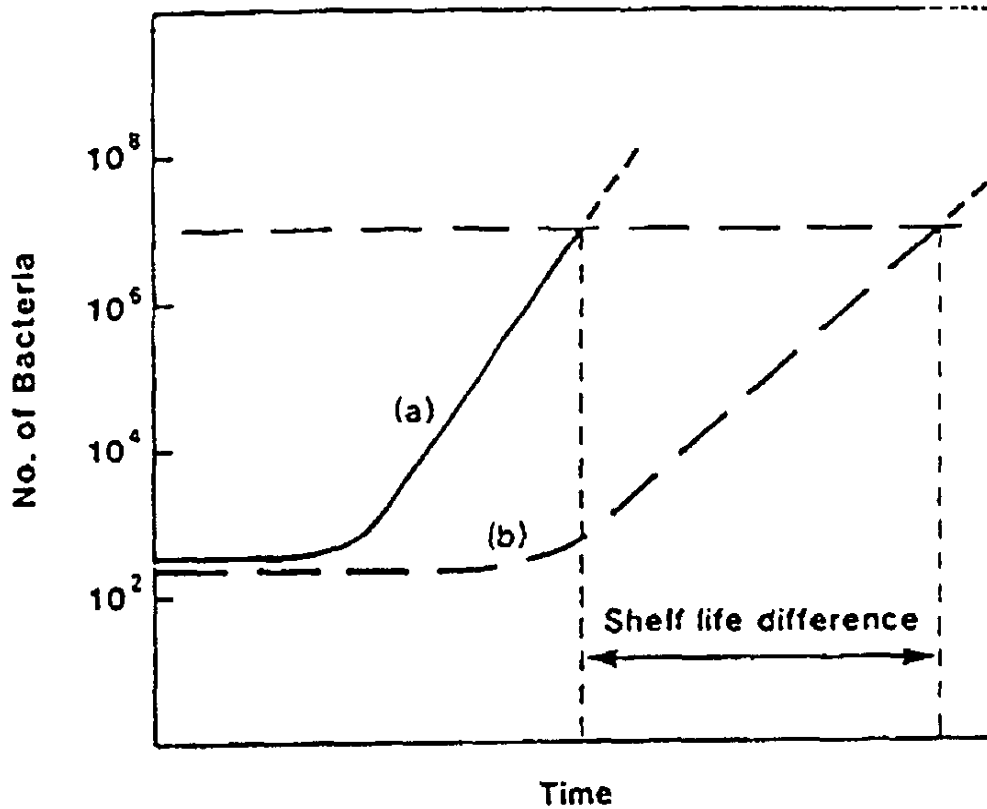
2.19.4 Moisture

Like all living organisms, bacteria need water to grow. Prevention of bacterial growth by drying is the oldest method of preserving meat. Generally, bacteria need more water than either moulds or yeast and this must be available water, that is, it must not be bound too firmly by salt, sugar or other solutes. Water activity is a measure of the availability of moisture to support bacterial growth. Removal of moisture from a product or the lowering of its water activity (e.g. by addition of salt) will result in a decrease of growth rate.

2.19.5 Gaseous Environment

Composition of the atmosphere surrounding the product has a profound effect on the growth of many of the bacteria found on meat (Figure 5). Some organisms, for example the spoilage bacteria *Pseudomonas*, can only grow if they have oxygen and are termed 'aerobic'. However, some for example *Clostridium* can only grow in the absence of oxygen and they are termed 'anaerobic'. The third group in this category can grow with or without oxygen and they are referred to as 'facultative anaerobes' e.g. *Lactobacillus*.

Under normal chilled storage conditions, the numbers of aerobic spoilage bacteria quickly reach a level where sliming and odours indicating that the meat is 'off' occurs.



- (a) Product temperature too high - short lag phase; rapid growth
- (b) Product temperature satisfactory - long lag phase; slow growth

Figure 3. The relative effect of storage temperature on shelf life
 Source: www.google.bacterialgrowth.curve Accessed 20/9/2012

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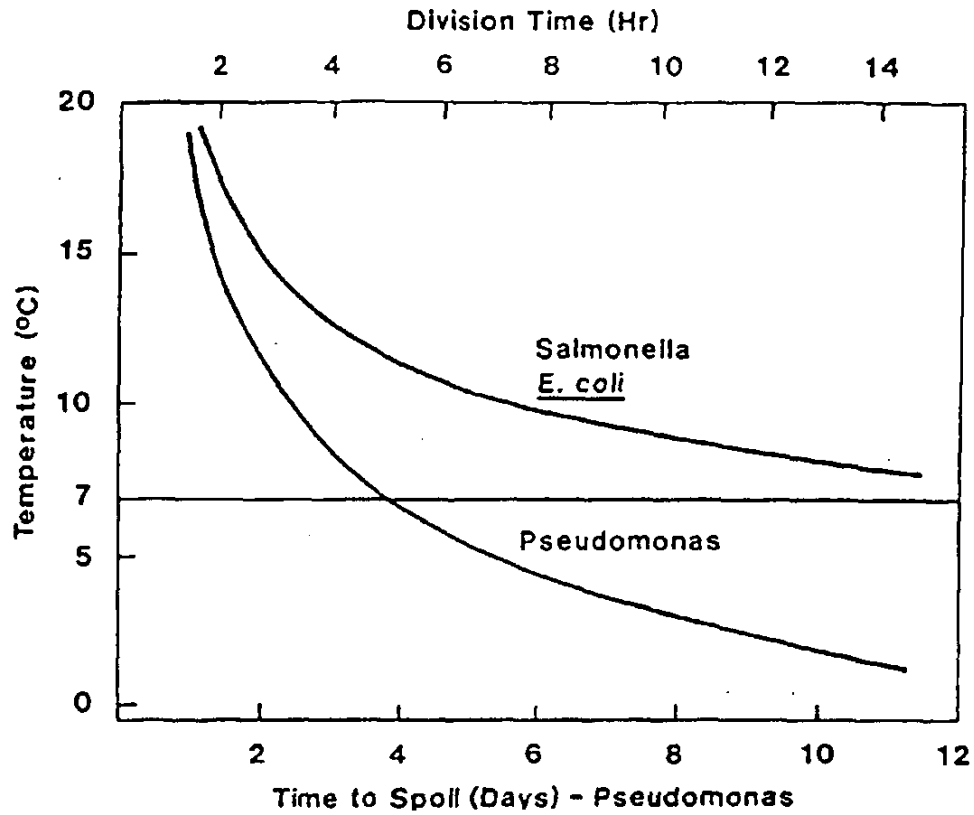


Figure 4: The effect of temperature on the growth of *Pseudomonas* and corresponding effect on *Salmonella*

Source: www.google.bacterialgrowth.curve Accessed 20/9/2012

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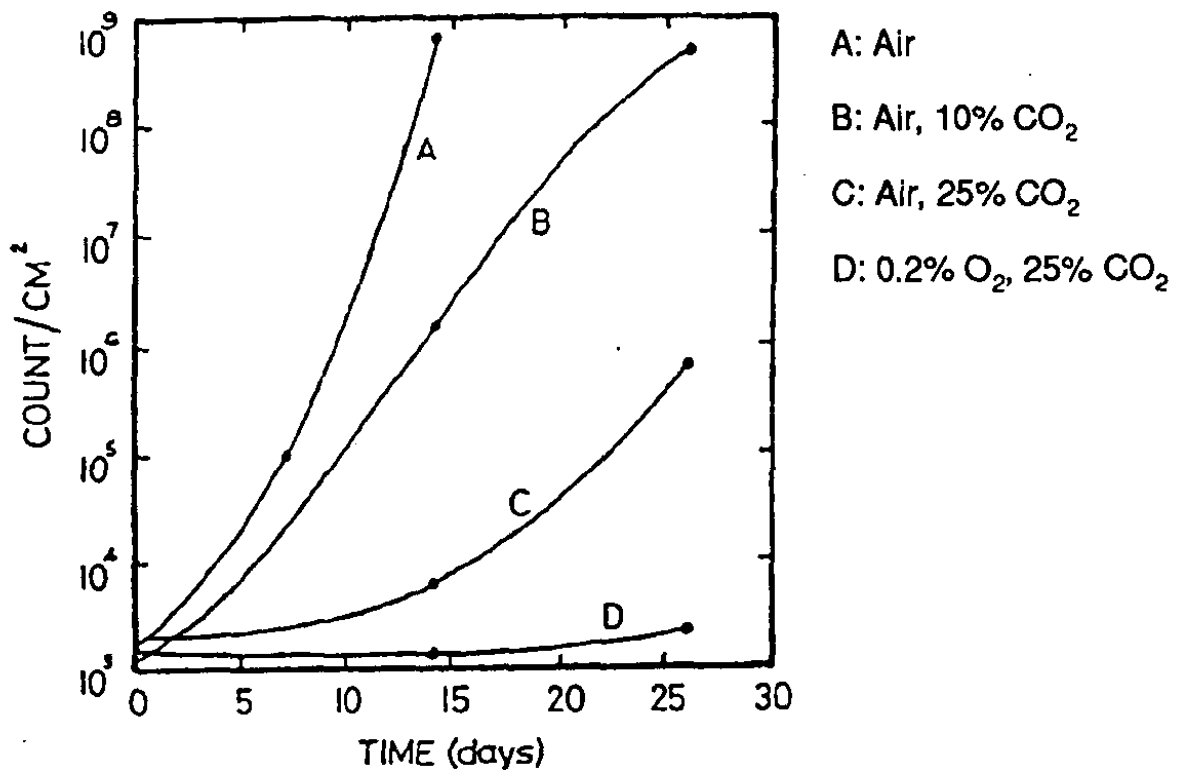


Figure 5. Effect of gaseous environment on growth of spoilage bacteria (*Pseudomonas*)

Source: www.google.bacterialgrowth.curve Accessed 20/9/2012

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If this spoilage bacterium could be replaced with a group which did not have such a severe effect on the meat, the chilled storage life of the product could be extended. This is achieved with vacuum packaging and modified-atmosphere packaging.

The high carbon dioxide environment inside the vacuum pack or modified-atmosphere pack is such that the aerobic spoilage pseudomonas will not grow and they will be replaced by lactobacilli which are facultative as the dominant organisms. These lactobacilli are not harmful. The end of the storage life will be determined by the eventual build-up of bacterial end products resulting in an unacceptable flavour and off-odour. If a putrid odour exists, it is mostly likely that the pack has been damaged thereby allowing a return to aerobic conditions and the resulting growth of aerobic spoilage organisms.

Conversely, the high oxygen environment inside a modified retail-ready pack may give good colour to the meat with high level of oxymyoglobin but will also allow faster growth of a number of spoilage bacteria than those in vacuum packs or high carbondioxide modified-atmosphere packs.

2.19.6 pH

Most bacteria grow over a pH range of between 4 and 8, but optimum growth usually occurs at or near pH 7. Below pH 6, bacterial growth of some strains is reduced markedly, some organisms which produce greening in vacuum-packaged meat is as a result of a low pH (below 6.0) of the meat (Figure 6). Most post-rigor muscle has a pH in the range of 5.4-5.8 and the bacteria on this type of meat will grow more slowly than bacteria on 'dark-cutting' meat which has a pH of 6.0 or more.

2.19.7 Initial Bacteria Numbers

The initial numbers of bacteria are a direct result of the level of contamination that occurs during slaughtering and processing. The higher the initial number of bacteria, the faster the product will spoil. If the growth factors remained constant, the shelf life of the product would be determined solely by the initial number of bacteria on the product. Invariably, any reduction in hygiene standards or use of poor techniques will result in reduced shelf life of the meat (Figure 7).

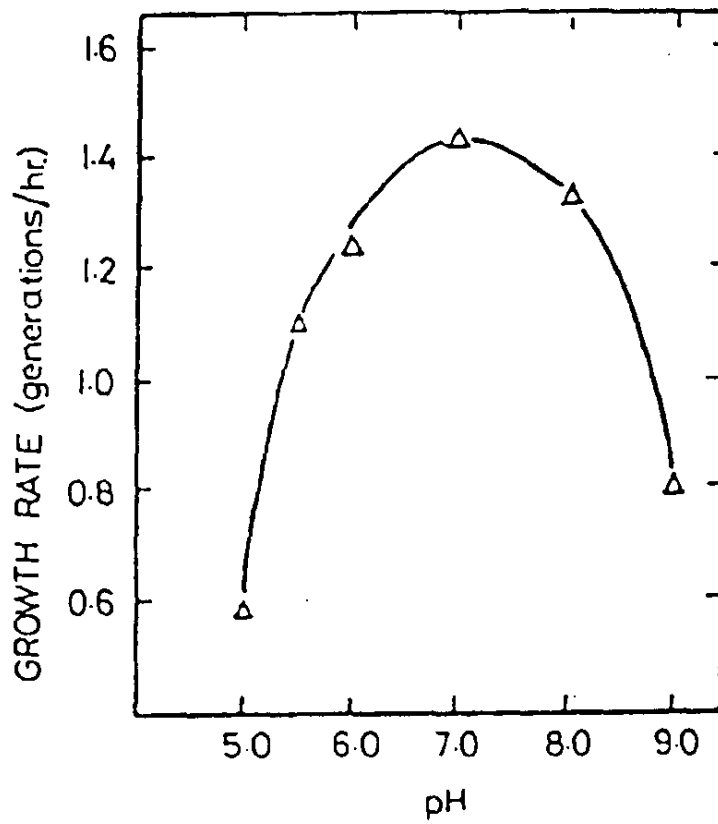
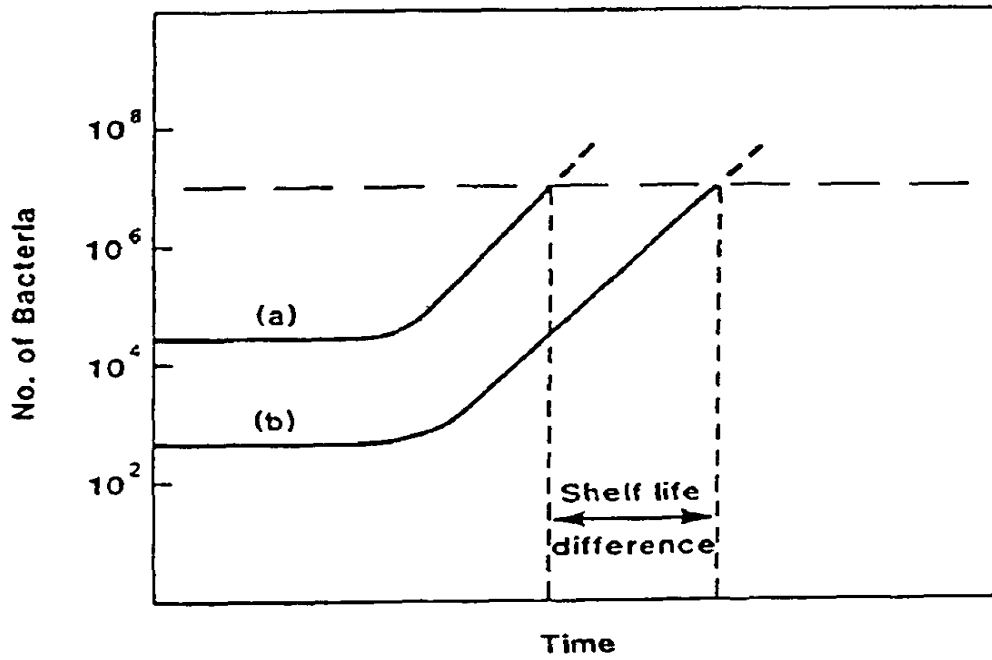


Figure 6. Effect of pH on the growth of *B. thermosphacta*

Source: www.google.bacterialgrowth.curve Accessed 20/9/2012

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(a) Product with high initial bacterial count

(b) Product with satisfactory initial bacterial count

Figure 7. The effect of initial bacteria numbers

Source: www.google.bacterialgrowth.curve Accessed 20/9/2012

2.20 Impact of Packaging on Meat Preservation

In most developing countries meat carcasses are handled and stored either without or with only minimal refrigeration. A fast-turnover system is used, ensuring that meat slaughtered during the night and morning is sold and consumed the same day. This well-proven traditional method functions satisfactorily because in the short period between slaughtering and consumption, micro-organisms cannot increase to the extent of spoiling the meat and making it inedible.

In traditional meat handling, fresh meat is generally not packaged at all or just wrapped in paper, leaves, etc. Meat, traditionally preserved by drying, is sometimes packaged in linen bags, baskets or pottery to facilitate storage and transport and to provide some kind of protection against dirt, insects, etc.

With higher concentrations of population, however, this traditional system now becomes outdated in some places in developing countries because more time is needed between slaughtering and ultimate consumption. Meat frequently has to be stored, transported, prepared and distributed through a retailer or supermarket, all of which is considerably time-consuming. In order to safeguard fresh meat during this extended time, certain methods of preservation have to be applied. Refrigeration is the obvious solution, but this is expensive and therefore frequently not available in developing countries. Energy-saving storage methods are therefore particularly relevant in underdeveloped areas. For both methods, either using the refrigeration technology or energy-saving methods to extend the shelf-life of meat and meat products, proper packaging has an important part to play.

2.21 Importance of packaging

It is well known that packaging makes food more convenient and gives the food greater safety assurance from microorganisms, biological and chemical changes so that the packaged foods may have a longer shelf life. As a result, packaging has become an indispensable element in the food manufacturing process and in order to meet the huge demand of the food industry, there has been a remarkable growth in the development of food packaging in the past decades (Skandamis and Nychas, 2002).

Packaging serves series of purposes to food processors and such benefits could be seen in terms of:

- improved protection for the food and an increased shelf-life,
- better quality products reaching the consumer,
- more attractive products to compete with other manufacturers,
- easily identifiable products for consumers to select from retail shops,
- sometimes re-usable containers,
- tamperproof packages reduce the risk of adulteration,
- making foods more easily handled and stored by retailers and consumers, and
- increase production output as a longer shelf-life enables a larger market to be found and year round production possible.

Traditionally, packaging should reduce the access of oxygen (practically, the complete removal of oxygen is not possible, even in the case of vacuum-packaging), water vapor, light and microbiological contaminations (Cierach and Stasiewicz, 2007).

Packaging is the last step in the production process and needs to be standardized if high quality meat is to be obtained (Insausti *et al.*, 2001). Appropriate packaging of meat and meat products bestow many benefits: exclusion of contamination with attendant extended maintenance of quality, delay of microbial spoilage, maintenance of desirable colour and minimization of water loss. The extension of storage life makes wider geographical distribution of the packaged products possible. Other benefits include greater handling convenience, improved presentation for retailers and the provision of a surface on which a printer attractive informative graphics can be displayed.

Realization of these benefits is contingent upon the correct selection of packaging materials and systems. The specific requirement depend upon whether the product to be packaged is fresh or processed meat; whether it is beef, lamb or pork; whether it is uncooked or cooked; boneless or bone-in; and whether it is destined for local retailer or for overseas destination. However, ideal packaging techniques should maintain the appearance of meat during storage, and delay oxidation and microbial spoilage.

2.22 Types of packaging materials

A. Textiles

Textile containers have poor gas and moisture barrier properties and have a poorer appearance than plastics. Woven jute sacks, which are chemically treated to prevent rotting and to reduce their flammability, are non-slip, have a high tear resistance, and good durability. They are used to transport a wide variety of bulk foods including grain, flour, sugar and salt

B. Cotton

Calico is usually a closely woven, strong, plain, cotton fabric which is inexpensive and is satisfactory as a wrapper for flour, grains, legumes, coffee beans and powdered or granulated sugar. It can be re-used as many times as the material withstands washing and is easily marked to indicate the contents of the bag.

C. Sisal

Sisal is a fibre that comes from the agave family of plants. Sisal is resistant to salt water and therefore makes an ideal natural material from which to make rope. The nets in which hard fruits are transported are often hand-made from vegetable fibre.

D. Wood

Wooden shipping containers have traditionally been used for a wide range of solid and liquid foods including fruits, vegetables, tea and beer. Wood offers good mechanical protection, good stacking characteristics and a high weight-to-strength ratio.

E. Metal

Metal cans have a number of advantages over other types of container: they provide total protection of the contents, they are convenient for ambient storage and presentation and they are tamperproof. However, they are heavier than other materials, except glass.

F. Glass

Glass containers have the following advantages:

- they are impervious to moisture, gases, odours and micro-organisms
- they are inert and do not react with or migrate into food products
- they are suitable for heat processing when hermetically sealed
- they are re-useable and recyclable
- they are resealable

- they are transparent to display the contents
- they are rigid, to allow stacking without container damage.

However, they possess some disadvantages which include:

- higher weight which incurs higher transport costs than other types of packaging
- lower resistance than other materials to fractures, scratches and thermal shock
- more variable dimensions than metal or plastic containers
- potentially serious hazards from glass splinters or fragments in foods .

G. Casings

Casings have been utilized in the production of sausage and processed meat products. Casings are referred to as the oldest form of packaging materials for sausage. They determine the final size and shape of the sausage product and serve as processing molds and containers during handling and shipping, and as merchandising units for display (INSCA, 2011).

Casings are made of two basic materials, cellulose or collagen. Five specific casings are generally used in the production of sausage products. These include animal, regenerated collagen, cellulose, fibrous and plastic casings.

(i) Natural Casings

Natural casings come from the gastro-intestinal tract (intestine) of animals such as cattle, hogs, and sheep. Natural casings are made from the sub-mucosa, a largely collagen layer of the intestine, having removed the fat and the inner mucosa lining. It has the advantages of traditional appearance, traditional texture and cooking performance that is expected of sausage. Its disadvantages include decreased machinability, reduced uniform weight or length and cost (Wenther, 2011).

(ii) Beef Casings

The three most used beef casings are: beef bung caps, beef rounds, and beef middles. The beef casings come in a variety of sizes depending on which type is used (e.g. bung caps, rounds or middles). Beef bung caps are used for large diameter sausage such as bologna and salami, beef rounds have the characteristic ring or round shape that are used in the production of ring bologna and polish sausage while beef middles can be sewn so that the final product will have a uniform diameter and uniform length. Beef bladders can also be used in the production of large diameter

sausages such as specialty sausage (souise or head cheese) and these are the largest diameter of casings from cattle and are oval in shape.

(iii) Hog Casings

Hog casings are used for smaller diameter (30-44 mm) sausages. These casings can be used for fresh sausage as well as fully cooked smoked sausage. After cleaning, hog casings are measured /sized to ensure a more uniform/size and shape to achieve uniform portion control of the final product. They are transparent and consumer can see the particle definition of the meat and the ingredients used in the sausage.

(iv) Sheep Casings

Sheep casings are the smallest (16-28 mm) of the natural casings that are commercially available. They are the most tender and the most adaptable to fresh pork sausage, which are sold fresh. These casings can also be used in the production of high quality frankfurters.

(v) Regenerated Collagen Casings

Regenerated collagen casings have many of the physical properties of animal casings. Collagen casings are being used to simulate natural casings. Collagen casings are essentially produced from the same material "chemically" and this material being collagen. The collagen originates from the corium layer of the hide of beef animals.

The corium is extracted with alkaline solution to remove the soluble components and washed with potable water. The collagen is then swollen with acid to give a viscous mass of acid collagen that is pushed through an annular die to form a tube. The tube is fixed by moving it through an alkaline bath, and the neutralized collagen returns to its original state. The tube is dried and cut to size. The casings can be shirred into sticks for faster production.

The advantages of utilizing collagen casings relate to the availability of these casings in a variety of sizes (INSCA, 2011). The collagen casings work well when machine-handled because they can produce uniform diameters to reduce the "give-away" of sausage, which in turn affects final profit. Collagen casings are edible which means that the sausage do not need to be peeled after thermal processing.

(vi) Cellulose Casings

Cellulose casings include those made from cotton bags and those derived from processed cotton lintners. The cloth bags give a high degree of uniformity to the encased sausage product. Cotton

linters are a fine fuzz-like material that is removed from cottonseed after the cotton fiber and seed have been separated at the cotton gin.

Cellulose casings are permeable to smoke, which gives the final product good consumer eye appeal. The casings are also permeable to moisture to some extent. Cellulose casings are impermeable to organic molecules such as meat emulsion (INSCA, 2011; Wenther, 2011).

Cellulose casings come in a variety of sizes, but are generally divided into two categories - small diameter and large diameter.

(vii) Fibrous Casings

Fibrous casings, also known as large diameter cellulose casings, are made by impregnating a strong paper like material with cellulose. Fibrous casings have good machinability and uniformity which adapts well to high speed operations. Fibrous casings are manufactured in such a manner that they adhere to the sausage surface, which is important in the production of dry and semi-dry sausage. There are a variety of fibrous casing sizes which give processed meat processors a great number of choices to fit market preferences.

(viii) Plastic Casings

In some processed meat applications, a moisture impermeable casing is best suited. The recognized product made using plastic casings is braunschweiger. The impermeable material used to produce plastic casings is PVDC.

Any casing which is impermeable to moisture is also impermeable to smoke. Therefore, any smoke flavoring must be incorporated directly into the product during manufacturing. Plastic casing can also be produced in a variety of sizes and colors to increase the visual appeal to the consumers (INSCA, 2011; Wenther, 2011).

H. Plastics

The range of plastics and co-polymers used to make rigid plastic food containers is wide. For most small food processors the choice will be restricted to packaging made of polypropylene, polythene and polyvinylchloride (PVC). However, polyethylene tetraphthalate (PET) is rapidly becoming more common. For the food processor, plastic containers have the great advantages of: low cost, lightness, resistance to impact damage, availability both in clear and colored types.

None the less, plastic containers give less protection than colored glass against light and air. In addition, they are not as strong, in terms of weight bearing and crushing, as glass and are easily

punctured by sharp objects. In general, they cannot be easily re-used or re-cycled. Example commonly found is **Polyethylene**.

Polyethylene is divided into high density and low density polyethylene. The difference is that high density polyethylene is stronger, thicker, less flexible and more brittle than low-density polyethylene and has lower permeability to gases and moisture. Polyethylene has a high tear strength, penetration resistance and seal strength. They are waterproof and chemically resistant.

I. Polyamide

Polyamide is a clear glossy film with a low strength and is susceptible to puncture. It has moderate permeability to moisture, gases and odours (Wenther, 2011).

2.23 Meat floss

Foods of animal origin such as meat and meat products contain important nutrients like amino acids, vitamins, minerals and fatty acids which are essential for growth and development (Abubakar *et al.*, 2011). Animal products such as dressed carcass or fresh meat, egg and milk are highly perishable because of their high nutritional value especially the moisture content. Also, the presence of easily usable carbohydrates, fats, and proteins provide ideal environments for microbial spoilage. Microbial growth (and spoilage of food) is controlled by both intrinsic or food related factors and extrinsic or environment related factors (Prescott *et al.*, 2002). The intrinsic factors include pH, moisture content, water activity or availability, oxidation-reduction potential, physical structure of the food, available nutrients, and the possible presence of natural antimicrobial agents while the extrinsic factors include temperature, relative humidity, gases (carbon dioxide, oxygen) and the types and numbers of microorganisms present in the food.

Exploitation of all avenues of meat preservation has been suggested but these methods rarely achieve their aim due to their sophistication, which requires constant and reliable power supply that is almost absent in most developing countries (Abubakar, *et al.*, 2011). Therefore, evaluation of simple, appropriate and affordable technologies applicable to local environment is pertinent. To prevent spoilage, meat may be processed into products using many techniques such as intermediate moisture processing. Food preservation involves the process of inhibiting;

- i) the growth and activity of microorganisms,
- ii) activity of endogenous enzymes,
- iii) chemical reactions which may deteriorate the quality of foods, and

iv) invasion and spoilage by insects and rodents (Sivasankar, 2005).

Further processing of meat offers the opportunity to add value, reduce prices, improve food safety and extend shelf-life, resulting in increased household income and improved nutrition (FAO, 2010). Furthermore, growing consumer interest in foodstuffs of high nutritional value that guaranteed a health from toxicological point of view and proper hygienic conditions has prompted interest in different processed meat products and one of such products is called meat floss.

Meat floss/shredded meat is a dehydrated meat product is one of the traditional meat based product popular among Malaysians and the Asian community (Huda *et al.*, 2012) while in Nigeria it is a popular traditional meat product among the Northerners that has been produced for years and popularly known as *danbunama* (Ogunsola and omojola, 2008).

Due to its low moisture content, meat floss can keep without refrigeration and will not drastically change in room temperature storage (Ockerman and Li, 1999). It can be consume as part of the daily dish or consume with lemang (glutinous rice cooked in bamboo tubes) in Malaysia (Huda *et al.*, 2012) while Ockerman and Li (1999) reported that apart from consuming it as part of daily diet, it can also be consumed as snacks.

Raw materials such chicken, beef and fish are suitable for meat floss preparation (Ogunsola and omojola, 2008; Huda *et al.*, 2012) but its preparation from non-ruminant such as rabbit and poultry products have also been reported (Abubakar *et al.*, 2011) .

Its preparation varies within individuals, for instance in Malaysia its preparation generally starts with steaming of washed meat until it is tender. The meat is then shredded into fine particles and mixed with spices and coconut milk and afterwards the mixture is fried (Huda *et al.*, 2012), while Ockerman and Li (1999) reported the addition of lard of different levels before frying the mixture. However, in Nigeria it involves cutting meat into chunks, followed by boiling, shredding and finally frying. During cooking and frying, spices composition which consists of various spices such as pepper, salt, cloves ginger curry, thyme etc are added (Ogunsola and omojola, 2008). The types and proportions of these ingredients also vary within individuals. All these variability indicated that there is no standard preparation of meat floss.

The report of Ockerman and Li (1999) showed that moisture content of pork floss they worked on ranged from 0.235 - 3.47%. Huda *et al.* (2012) revealed that the moisture content of meat floss samples they worked on were within the range of 8.60-13.56% while lower moisture content (6.50- 7.37%) was reported by Ogunsola and Omojola (2008). Laksono and Syahrul (2001) reported a moisture contents of between 3.64-9.78% for shredded fish while in Indonesia, it is reported that the moisture content of shredded meat product should be lower than 7% (Fachruddin, 1997).

Fat content between 3.20-31.14 % of meat floss samples were reported by Huda *et al.* (2012). But Ockerman and Li (1999) reported that the addition of 2% and 12% lard will produced meat floss with a fat content of 16.89 and 31.33%, respectively. Higher fat contents (35.57-40.85%) were reported by Ogunsola and Omojola (2008) while Fachruddin, (1997) stated that the standard fat content for shredded meat product should be lower than 30%.

Huda *et al.* (2012) reported a protein content of meat floss samples to fall within the range of 19.86-30.15% while Ogunsola and Omojola (2008) reported a higher protein content of 38.92-41.21%. Similar protein content 34.09-42.90% was also reported for pork floss by Ockerman and Li (1999). While Fachruddin (1997) concluded in his report that the protein of shredded meat product should be more than 15%.

Ash contents within the range of 3.17-5.16% was reported by Huda *et al.* (2012). Laksono and Syahrul (2001) reported ash content within the range of 5.52-6.80% for shredded fish while in Indonesia it was reported that ash content of shredded meat product should be below 7% (Fachruddin, 1997). However, the study of Abubakar *et al.* (2011) revealed that meat floss from non ruminant such as rabbit contain 59.2% protein, 24.3% ether extract and 5.3-7.4% ash content.

However, since this product is still being prepared mainly by the traditional home-made method in Nigeria, there may be some hygienic challenges. The detailed chemical and microbiological study is needed to improve the quality, increase availability, shelf life stability and acceptance of this dried meat product.

Chapter Three

3.0 Socio-economic baseline survey of meat floss production and consumption

3.1 Introduction

Processed meat products, although are still new in some regions, they are globally gaining ground in popularity and consumption volume (Heinz and Hautizinger, 2007). To generate information essential for the production and consumption of a particular meat product suitable for producers and consumers, a survey aimed at defining the socio-economic characteristics of the producers and consumers needs to be evaluated.

Survey of producers will give information on the various ways by which such product can best be produced, the market strategy and the income generating ability of the product. Survey of the consumers concerning meat product consumption preferences and willingness to pay for special meat product is very important when considering the sustainability of that particular product (Curtis *et al.*, 2012).

Consumer tests are the principal tools used to design more desirable products (González-Viñas *et al.*, 2004). They are used for product maintenance, product optimization, new product development and evaluation of market potential (Meilgaard *et al.*, 1987). Consumers who purchase meat products want affordability and healthy product, however, a consumer will repeatedly buy a product if it tastes good (National Research Council, 1988). The consumer test data are important because the consumers are the final users of the product (Muños and Chamber, 1993).

The production of meat floss is still at its infancy in Nigeria. While the product is less popular in the Southern part of the country, the elites in the Northern part are familiar with it.

Meat floss is a product that is not too popular, therefore, its production and consumption pattern need to be evaluated for product sustainability. Hence, this study was carried out to assess the production and consumption pattern of meat floss among the populace within the country with the view of increasing its acceptability.

3.2 Materials and Methods

3.2.1 Site of the study

Four cities (Abuja, Kaduna, Ibadan and Lagos) were purposely chosen for the study. All major meat products markets and superstores were identified within each of the chosen city for the study.

3.2.2 Sampling procedure

Two sets of structured questionnaires were administered, one set for the consumers and the other for the producers. A total of 200 questionnaires were administered for consumers in the four cities at 50 per city, but a total of 184 were retrieved (Table 2). However, only a total of 50 questionnaires could be administered and retrieved from the producers in the four cities. Consumers were randomly sampled in each market while producers were painstakingly sought for.

3.2.3 Instruments for data collection

Each of the questionnaires consists of two sections.

Section A seeks demographic information of the consumer/producer while section B seeks the consumption or production pattern of the respondents as regards meat floss.

A sample of each questionnaire is shown in appendices 1 and 2.

3.2.4 Data analysis

Data collected were subjected to simple descriptive analysis using the SAS (1999) package.

Table 2. Number of questionnaires administered on consumers and producers in the meat products markets in Abuja, Ibadan, Lagos and Kaduna.

Cities	Number of Questionnaires			
	Administered		Retrieved	
	Consumers	Producers	Consumers	Producers
Abuja	50	07	46	07
Ibadan	50	15	43	15
Lagos	50	08	47	08
Kaduna	50	20	48	20
Total	200	50	184	50

3.3 Results

3.3.1 Demographic characteristics of producers of meat floss in Abuja, Ibadan, Lagos and Kaduna

The demographic characteristics of producers of meat floss in the four cities are presented in Table 3. On gender basis, the male producers were 28.57, 33.33, 75.00 and 25.00% while the female producers were 71.43, 66.67, 25.00 and 75.00% in Abuja, Ibadan, Lagos and Kaduna respectively. Most of the producers fall within the age range of 26-40 years with 71.43%, 100%, 75.00% and 65.00% in Abuja, Ibadan, Lagos and Kaduna respectively. However, 28.57%, 25% and 35% of the producers in Abuja, Lagos and Kaduna respectively were above forty (40) years of age.

In all the four cities, all (100%) of the producers were married. Also, all of them (100%) were from the Hausa tribe.

The results showed that in Abuja, Ibadan, Lagos and Kaduna respectively, 42.86%, 26.67%, 57.14% and 50.00% were primary school leavers while 42.86%, 66.67%, 42.86% and 50% were secondary school leavers. However, 14.28% and 6.67% of the producers in Abuja and Ibadan respectively had up to tertiary level education. No producer in Lagos and Kaduna had up to tertiary education.

The producers making a monthly earning of between ₦21,000 - ₦40,000 were 71.43%, 53.85%, 25% and 15% in Abuja, Ibadan, Lagos and Kaduna respectively. The producers earning between ₦11,000 - ₦20,000 were 75% (Kaduna), 62.50% (Lagos) and 46.15% (Ibadan). However, the producers earning between ₦5,000 - ₦10,000 were 28.57% (Abuja), 12.50% (Lagos) and 10% (Kaduna).

Table 3: Demographic characteristics of producers of meat floss in Abuja, Ibadan, Lagos and Kaduna meat markets.

		ABUJA		IBADAN		LAGOS		KADUNA	
		No	%	No	%	No	%	No	%
Sex	Male	2	28.57	5	33.33	6	75.00	5	25.00
	Female	5	71.43	10	66.67	2	25.00	15	75.00
Total respondent		7		15		8		20	
Age	26-40	5	71.43	15	100.00	6	75.00	13	65.00
	41&above	2	28.57	-	-	2	25.00	7	35.00
Total respondent		7		15		8		20	
Marital status									
Single		-	-	-	-	-	-	-	-
Married		7	100.00	15	100.00	8	100.00	20	100.00
Total respondent		7		15		8		20	
Tribe									
Hausa		7	100.00	15	100.00	8	100.00	20	100.00
Igbo		-	-	-	-	-	-	-	-
Yoruba		-	-	-	-	-	-	-	-
Total respondent		7		15		8		20	
Education:									
Primary		3	42.86	4	26.67	4	57.14	10	50.00
Secondary		3	42.86	10	66.67	3	37.50	10	50.00
Tertiary		1	14.28	1	6.67	-	-	-	-
Total respondent		7		15		7		20	
Income									
5,000 - 10,000		2	28.57	-	-	1	12.50	2	10.00
11,000 - 20,000		-	-	6	46.15	5	62.50	15	75.00
21,000 - 40,000		5	71.43	7	53.85	2	25.00	3	15.00
Total respondent		7		13		8		20	

3.3.2. Production status of meat floss and other meat products in Abuja, Ibadan, Lagos and Kaduna

The response of producers to meat floss production is shown in Table 4. The result revealed that most of the producers in these cities (85.71% Abuja), (60% Ibadan), (87.50% Lagos) and (89.47% Kaduna) had been in meat products business for more than five years, while 14.29%, 26.67%, 12.50% and 10.53% of the producers in Abuja, Ibadan, Lagos and Kaduna respectively have only been in the business of meat floss production between 1-5 years. However, some producers in Ibadan (13.33%) have been in the business for more than 10 years.

Majority of the producers sampled in the cities were engaged only in the production of meat floss while only 14.29% (Abuja), 20% (Ibadan) and 10% (Kaduna) of the producers approached produced only *Suya*.

Most of the producers in Abuja (57.14%), Ibadan (93.33%) and Kaduna (60%) produced their meat floss from beef only, while 42.86% (Abuja), 100% (Lagos) and 40% (Kaduna) produced meat floss from both beef and poultry.

All the producers (100%) in the four cities use only the thigh muscle/part for meat floss production.

All the producers (100%) in Abuja while 93.33%, 75% and 85% of the producers in Ibadan, Lagos and Kaduna respectively made as much as twice their cost of production as profit. However, 6.67%, 25% and 15% of the meat products producers in Ibadan, Lagos and Kaduna made up to three times their cost of production as profit.

All producers (100%) in Abuja claimed that they have a ready market for their product while only 66.67%, 25% and 52.63% of the producers in Ibadan, Lagos and Kaduna respectively have a ready market for their product. From the information, higher percentage of producers in Lagos, followed by Kaduna and Ibadan claimed that they do not have ready market for their product.

The result also revealed that none of the producers in Abuja have any leftover of their product for storage while 80%, 87.50% and 60% of the producers in Ibadan, Lagos and Kaduna respectively stored the leftover of their produce in a sealed containers and 20%, 12.50% and 40% of the producers in Ibadan, Lagos and Kaduna respectively stored the leftovers of their product in wrapped paper.

Table 4: Producer's response to production of meat floss and other meat product in four different cities

	ABUJA		IBADAN		LAGOS		KADUNA	
	No	%	No	%	No	%	No	%
Years in business								
1-5	1	14.29	4	26.67	1	12.50	2	10.53
6-10	6	85.71	9	60.00	7	87.50	17	89.47
10& above	-	-	2	13.33	-	-	-	-
Total respondent	7		15		8		19	
Types of products								
Suya	1	14.29	3	20.00	-	-	2	10.00
Kilishi	-	-	2	13.33	-	-	-	-
Meat floss	5	71.43	10	66.67	6	85.71	9	45.00
Kilishi & meat floss	1	14.29	-	-	1	14.29	9	45.00
Total respondent	7		15		7		20	
Types of meat used:								
Beef	4	57.14	14	93.33	-	-	12	60.00
Chevon	-	-	1	6.67	-	-	-	-
Poultry	-	-	-	-	-	-	-	-
Beef & poultry	3	42.86	-	-	8	100.00	8	40.00
Total respondent	7		15		8		20	
Part of meat used:								
Thigh	7	100.00	15	100.00	8	100.00	20	100.00
Shoulder meat	-	-	-	-	-	-	-	-
Back	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-
Total respondent	7		15		8		20	

Table 4 continued: Producer's response to production of meat floss and other meat product in four different cities

	ABUJA		IBADAN		LAGOS		KADUNA	
	No	%	No	%	No	%	No	%
Profit per production:								
2 times	7	100.00	14	93.33	6	75.00	17	85.00
3 times	-	-	1	6.67	2	25.00	3	15.00
Total respondent	7		15		8		20	
Ready market for product:								
Yes	7	100.00	10	66.67	2	25.00	10	52.63
No	-	-	5	33.33	6	75.00	9	47.37
Total respondent	7		15		8		19	
Storage of leftover:								
wrapped paper	-	-	3	20.00	1	12.50	8	40.00
Sealed container	-	100.00	12	80.00	7	87.50	12	60.00
Total respondent	-		15		8		20	

3.3.3. Demographic characteristics of Consumers of meat floss and other meat products in Abuja, Ibadan, Lagos and Kaduna

The demographic characteristics of the consumers of meat floss from four different cities as shown on Table 5 revealed that the percentage of the male respondents ranged between 53.48 and 72.34 with Kaduna city recording the highest (72.34%) number of consumers. The percentages of the female respondents were 46.50 (Abuja), 45.52 (Ibadan), 43.50 (Lagos) and 27.66 (Kaduna).

The percentage consumers that fell between age range 15 - 25 years were 26.09, 30.23, 28.89 and 61.67, and those in the age range of 26 – 40 years were 43.48, 42.86, 48.89 and 31.25 in Abuja, Ibadan, Lagos and Kaduna respectively. The percentages of respondents that are above 40 years of age in the cities were 2.08, 22.22, 27.91 and 30.43 in Kaduna, Lagos, Ibadan and Abuja respectively.

The respondents that are civil servants were more in Abuja (55.56%) followed by Ibadan (50.00%), Lagos (47.73%) and Kaduna (15.56%). Respondents that engaged in trading were 6.67% for both Abuja and Kaduna, 7.14% for Ibadan and 15.91% for Lagos.

The respondents with tertiary level of education ranged from 33.33% (Kaduna), 74.42% (Ibadan), 78.06% (Lagos) to 86.04% (Abuja). Those that were secondary school leavers were 6.52%, 11.63%, 23.25% and 62.50% in Lagos, Abuja, Ibadan and Kaduna respectively. Respondents with only primary school education were least in Abuja and Ibadan with a percentage of 2.33% for both cities, while that of Kaduna and Lagos were 4.17% and 15.22% respectively.

The percentage of respondents who earned a monthly income of ₦5,000 - ₦11,000 were highest (41.70) for Kaduna, followed by Ibadan (18.60%), Abuja (15.22%) and the least was Lagos (7.50). Percentages of respondents that earned between ₦11,000- ₦20,000 were 21.74%, 20.93%, 7.50% and 23.81% in Abuja, Ibadan, Lagos and Kaduna respectively, while those that earned between ₦21,000 - ₦40,000 were 17.39% (Abuja), 44.19% (Ibadan), 25.00% (Lagos) and 26.19% (Kaduna). Abuja (45.65%) and Lagos (60.00%) had the highest respondents that earned above ₦40,000 as their monthly income while Ibadan (16.38%) and Kaduna (2.38%) recorded the least respondents.

Table 5: Demographic characteristics of consumers of meat floss and other meat products in Abuja, Ibadan, Lagos and Kaduna

	ABUJA		IBADAN		LAGOS		KADUNA	
	No.	%	No.	%	No.	%	No.	%
Sex: Male	26	53.50	23	53.48	26	56.50	34	72.34
Female	20	46.50	20	46.52	20	43.50	13	27.66
Total respondent	46		43		46		48	
Age:15-25	12	26.09	13	30.23	13	28.89	32	66.67
26-40	20	43.48	18	42.86	22	48.89	15	31.25
> 41	14	30.43	12	27.91	10	22.22	1	2.08
Total respondent	46		43		45		48	
Occupation:								
Civil servant	25	55.56	21	50.00	21	47.73	7	15.56
Trader	3	6.67	3	7.14	7	15.91	3	6.67
Others	17	37.78	18	42.86	16	36.36	35	77.78
Total respondent	45		42		44		45	
Education:								
Primary	1	2.33	1	2.33	7	15.22	2	4.17
Secondary	5	11.63	10	23.25	3	6.52	30	62.50
Tertiary	37	86.04	32	74.42	36	78.26	16	33.33
Total respondent	43		43		46		48	
Income (₦):								
5,000-10,000	7	15.22	8	18.60	3	7.50	20	47.62
11,000- 20,000	10	21.74	9	20.93	3	7.50	10	23.81
21,000- 40,000	8	17.39	19	44.19	10	25.00	11	26.19
Above 40,000	21	45.65	7	16.28	24	60.00	1	2.38
Total respondent	46		43		40		42	

3.3.4. Consumers response to purchase and preservation of meat and meat products in

Abuja, Ibadan, Lagos and Kaduna

The results on Table 6 shows the response of consumers to type of meat and meat products purchased as well as the preservation method employed for their meat. The result revealed that in Abuja, Ibadan, Lagos and Kaduna respectively 62.22%, 55.81%, 89.13% and 74.47% of respondents respectively purchased beef, 2.22%, 2.23%, 2.17% and 4.26% purchased pork and 22.22%, 27.91%, 4.35% and 17.02% purchased poultry meat. While, none of the respondents in Lagos purchased chevon but 8.90%, 11.63% and 2.13% of respondents in Abuja, Ibadan and Kaduna respectively purchased chevon. However, 4.44% (Abuja), 2.33% (Ibadan), 4.35% (Lagos) and 2.13% (Kaduna) respondents claimed that they purchased other meat types apart from those listed in the survey questionnaire.

A total of 47.83% respondents in (Abuja), 58.14% (Ibadan), 21.74% (Lagos) and 52.08% (Kaduna) engaged freezing as a method of preserving their meat while 36.96% (Abuja), 25.58% (Ibadan), 60.87% (Lagos) and 8.33% (Kaduna) preserved their meat by roasting method. Salting (25%) and drying (14.58%) methods are most common among the Kaduna respondents. The percentages of respondents that engaged in drying of meat in Abuja, Ibadan and Lagos cities respectively were 13.04%, 13.85% and 15.22%, and those that used salting method were 2.17%, 2.33% and 2.17%.

Majority of the respondents in Abuja (77.27%), Ibadan (73.17%), Lagos (85.71%) and Kaduna (70.83%) claimed that they purchased processed meat while 22.73%, 26.83%, 14.29% and 14.29% respondents from Abuja, Ibadan, Lagos and Kaduna respectively claimed that they avoided purchasing processed meat.

High percentage of respondents (61.11%) from Kaduna followed by Abuja (56.76%), Ibadan (51.42%) and Lagos (12.50%) purchased *Suya* as their meat products, while the highest percentage of respondent (65%) from Lagos, followed by Kaduna (25%), Abuja (16.22%) and Ibadan (12.12%) claimed that they preferred to buy *Kilishi*. Percentage of respondents that purchased roasted chicken ranged from 5.00% in Lagos to 10.81% in Abuja. Barbecue is common among respondents in Ibadan (18.18%) and Lagos (15%) compared to 8.11% in Abuja and 2.78% in Kaduna. However, 8.11%, 9.09%, 2.50% and 5.56% of the respondents in Abuja, Ibadan, Lagos and Kaduna respectively claimed that they purchased other types of meat products besides those listed in the survey questionnaire.

Table 6: Consumers response to types of meat, meat product purchase and preservation methods in Abuja, Ibadan, Lagos and Kaduna

	ABUJA		IBADAN		LAGOS		KADUNA	
	No	%	No	%	No	%	No	%
Types of meat purchase:								
Beef	28	62.22	24	55.81	41	89.13	35	74.47
Pork	1	2.22	1	2.33	1	2.17	2	4.26
Poultry	10	22.22	12	27.91	2	4.35	8	17.02
Chevon	4	8.90	5	11.63	-	-	1	2.13
Others	2	4.44	1	2.33	2	4.35	1	2.13
Total respondent	45		43		46		47	
Preservation method:								
Freezing	22	47.83	25	58.14	10	21.74	25	52.08
Roasting	17	36.96	11	25.58	28	60.87	4	8.33
Drying	6	13.04	6	13.95	7	15.22	12	25.00
Salting	1	2.17	1	2.33	1	2.17	7	14.58
Total respondent	46		43		46		48	
Purchase of processed meat:								
Yes	34	77.27	30	73.17	36	85.71	34	70.83
No	10	22.73	11	26.83	6	14.29	14	29.17
Total respondent	44		41		42		48	
Types of product purchase								
Suya	21	56.76	17	51.52	5	12.50	22	61.11
Kilishi	6	16.22	4	12.12	26	65.00	9	25.00
Roasted chicken	4	10.81	3	9.09	2	4.00	2	5.56
Barbecue	3	8.11	6	18.18	6	15.00	1	2.78
Others	3	8.11	3	9.09	1	2.50	2	5.56
Total respondent	37		33		40		36	

3.3.5. Consumption of meat floss in Abuja, Ibadan, Lagos and Kaduna

Response of consumers to consumption of meat floss is presented in Table 7. The results revealed that 76.60%, 66.67%, 45.24% and 30.43% of the respondents in Kaduna, Abuja, Ibadan and Lagos respectively were familiar with meat floss.

The consumption pattern of meat floss among the respondents was highest in Kaduna (84.78%) followed by Abuja (65.91%), Ibadan (43.90%) and the least in Lagos (25.53%). The same trend observed for consumption pattern of meat floss was observed for familiarization trend of the product.

A total of 80.49% of respondents in Lagos followed by Ibadan (78.57%), Kaduna (71.43%) and Abuja (64.52%) claimed that they consume meat floss once in a while, whereas 19.51%, 21.43%, 28.57% and 35.48% of the respondents in Lagos, Ibadan, Kaduna and Abuja cities respectively consume meat floss frequently.

Higher percentage of the respondents (69.05%) in Lagos, followed by Abuja (57.14%), Ibadan (53.33%) and Kaduna (35.56%) only came across meat floss for the first time at a party, while 44.44% of the respondents in Kaduna, 36.67% in Ibadan, 28.57% in Abuja and 26.19% in Lagos claimed that they saw the product for the first time in the shop/market place. However, 4.76%, 10%, 14.29% and 20% of the respondents in Lagos, Ibadan, Abuja and Kaduna respectively claimed that they first came in contact with meat floss when it was hawked at motor parks.

A total of (25.58%) respondents in Ibadan followed by Kaduna (25%), Lagos (23.91%) and Abuja (15.22%) claimed that the price of meat floss is expensive while to 6.25% of the respondents in Kaduna, 11.63% in both Ibadan and Lagos cities and 11.90% in Abuja, the price of meat floss is relatively cheap. However, higher percentages of respondents (74.43%) in Abuja followed by Kaduna (68.75%), Lagos (65.22%) and Ibadan (62.79%) agreed that the price of the product is fair and affordable.

The of percentages of consumers that were concerned about the packaging methods of meat floss were 40% (Abuja), 34.29% (Ibadan), 32.56% (Lagos) and 25.58% (Kaduna) while 27.90% (Lagos), 36.67% (Abuja), 37.21% (Kaduna) and 45.71% (Ibadan) respondents claimed that the doubtful level of hygiene of meat floss has negatively affected their consumption/acceptance of meat floss. Fewer percentages of the respondents in Ibadan (5.71%), Abuja (6.67%), Lagos (11.63%) and Kaduna (13.95%) were concerned about the type of meat used for the production of

meat floss and only 14.29%, 16.67%, 23.26% and 27.91% of the respondents in Ibadan, Abuja, Kaduna and Lagos respectively were concerned about the combination of the spices used in the production of meat floss.

A total of 73.33% of the respondents in Kaduna followed by Abuja (70%), Ibadan (30.95%) and Lagos (9.09%) agreed that meat floss is available in their locality while 90.91%, 65.05%, 30% and 26.67% of the respondents in Lagos, Ibadan, Abuja and Kaduna cities claimed meat floss is not readily available in their locality.

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Table 7: Consumers response to consumption of meat floss in Abuja, Ibadan, Lagos and Kaduna

		ABUJA		IBADAN		LAGOS		KADUNA	
		No	%	No	%	No	%	No	%
Familiarity with meat floss:									
	Yes	30	66.67	19	45.24	14	30.43	36	76.60
	No	15	33.33	23	54.76	32	69.57	11	23.40
Total respondent		45		42		46		47	
Consumption of meat floss:									
	Yes	29	65.91	18	43.90	12	25.53	39	84.78
	No	15	34.09	23	56.10	35	74.47	7	15.22
Total respondent		44		41		47		46	
Freq of consumption:									
	Once a while	20	64.52	22	78.57	33	80.49	30	71.43
	Frequently	11	35.48	6	21.43	8	19.51	12	28.57
Total respondent		31		28		41		42	
Where ^{1st} seen:									
	At a party	20	57.14	16	53.33	29	69.05	16	35.56
	Shop / market place	10	28.57	11	36.67	11	26.19	20	44.44
	Hawked at motor parks	5	14.29	3	10.00	2	4.76	9	20.00
Total respondent		35		30		42		45	
Cost of product:									
	Expensive	7	16.67	11	25.58	11	23.91	12	25.00
	Cheap	30	74.43	27	62.79	30	65.22	33	68.75
	Fair	5	11.90	5	11.63	5	11.63	3	6.25
Total respondent		42		43		46		48	
Misgivings about product:									
	Type of meat used	2	6.67	2	5.71	5	11.63	6	13.95
	Type of Spice	5	16.67	5	14.29	12	27.91	10	23.26
	Type of Packaging	12	40.00	12	34.29	14	32.56	11	25.58
	Hygiene	11	36.67	16	45.71	12	27.90	16	37.21
Total respondent		30		35		43		43	
Availability in locality:									
	Yes	28	70.00	13	30.95	4	9.09	33	73.33
	No	12	30.00	29	69.05	40	90.91	12	26.67
Total respondent		40		42		44		45	

3.4 Discussion

3.4.1. Producers Response

The producers of meat floss in all the four cities are Hausa and most of them were aged between 26-40 years and most were female (full housewives). However, in Lagos most people that engaged in the production meat products were male. The high percentage of women in the business might probably be due to the fact that women in Hausa land are not allowed to go in search of white collar jobs. It is well known that majority of the women in Hausa land are full housewives and they engage in business/enterprises that will make them remain indoor. The production of meat floss served as a way of generating income at the confines of their homes.

The assessment educational background of the producers revealed that most of them were either primary or secondary school leavers with few having tertiary educational background. This might be due to the fact that the Hausa tribe does not allow their female children to acquire more than primary education and, most that go beyond primary education, still become full housewives and engage in business that will keep them indoor.

The low scale of production of most of the producers, especially producers in Kaduna and Lagos cities, is reflected in their income as most of them earn between ₦11,000 - ₦20,000 per unit of production (which is assumed to be the profit they made after sales). However, the higher income of producers in Abuja than other cities could be attributed to the fact that most of the producers claimed that they made the product, most times, on request from people. This probably made them to have control over the sale price, hence higher profit unlike situation in other cities where buyers trickled in and have to negotiate price before purchase.

Also, the result revealed that Abuja city had the highest percentage of producers with tertiary education, which could be an advantage for them in the provision of good packaging for the products. This will have added value to the product, make it more acceptable, and increase the sale price of the product which will in turn yield more profit. And this agrees with the report of Lennernas *et al.* (1997) that quality and healthfulness are among the most important factor that influences the choice of consumers for foods.

High percentage of the producers in all the four cities have been in the production business for more than 5 years and only in Ibadan city that few percentage of the producers claimed that they have been in the production business for more than 10 years. This is a complete aberration from the expected. However, this may be attributed to the high rate of migration of Hausa elites who

first settled in Ibadan before migrating further. Also, the earlier settlers had the opportunity of benefitting from the free education programme of the governments in Southwestern Nigeria.

Most of the producers approached produced meat floss only. However, in Kaduna, equal numbers of the producers (approached) produced meat floss and other variety of meat products, like *Kilishi*. This might be due to the fact that Kaduna is a cosmopolitan city in the North and the number of elites in the city is probably high, being the seat of Northern government for a long time.

All the producers from all the cities use thigh muscles of cow for meat floss production. This might be attributed to the fact that these animals, with the exception of poultry, have most of their meat located in the thigh muscles. Therefore, using the thigh muscles is an indication that more meat will be available for use and in the process increases the profit margin and this corroborate the report of Petracci *et al.* (2008) that the use of thigh meat in meat product formulation will minimize the production cost and this will in turn increase the profit margin.

Producers in Abuja made as much as twice their cost of production as profit, while few producers in other cities still made as much as thrice their cost of production. This may indicate that the production of meat floss as a commercial venture is profitable. The high profit claimed by Lagos producers could be as a result of the fact that the product is not popular in the city compared to Abuja and Kaduna. This might indicate that the few available products will be sold at high price to the informed buyers, which resulted in good returns to the producers. Also cash flow is high in Lagos and spendable income is also very high, hence consumers in Lagos could spend extra money on meat products.

Market availability is one of the hindrances to any producer and it indicates how long the producer can stay in the business. The survey revealed that it is only in Abuja that the producers had a ready market from the informed and elite customers who frequently requested for their products. The production on demand might also explain the absence of storage facility for the product among the Abuja producers. They had no reason for storing because they do not have leftovers. However in Lagos, high percentages of the producers do not have a ready market for their product. This might be attributed to low level of awareness of the product among the people and producers had to display the product in road-side advertisement to increase its awareness.

It is assumed that due to none availability of ready market for meat product among Ibadan, Lagos and Kaduna producers, they are left with no choice than to store the leftovers and a high percentage of them stored the remaining product after each day sales in a sealed container.

Comparing the percentage of producers that stored their leftovers in a wrapped paper, producers in Kaduna was highest. This might be attributed to the low level of education of the producers in this city, as most of them claimed to have up to secondary school level of education.

3.4.2. Consumers Response

From the consumer survey, there were more of male respondents in all the four cities. This supports the report of Gossard and York (2003) that gender has a particularly strong influence on meat consumption and there was no physiological reason, other than the average differences in weight that men would require more meat than women. This also corresponds with a survey of dietary habits in Denmark which showed that men consume more meat and meat products than women; on average of 141 g/day/man compared with 89 g/day/woman (excluding poultry) (Danish Institute for Food and Veterinary Research, 2005). Also, Linseisen *et al.* (2002), as cited by Williamson *et al.* (2005), reported that men consumed more of both red meat and processed meat than women.

The age of most of the respondents fell between 26 – 40 years and they were mostly civil servants. The high level of civil servant may be explained by the fact that the cities studied have long history of being seat of governments. However, the low (< 15%) civil servants who consumed meat products in Kaduna might be due to the presence of few industries other than civil service which engaged the people.

Majority of the respondents in Abuja, Ibadan and Lagos had higher level of education which provides work force for the government, hence high percentage of civil servants, unlike in Kaduna where the percentage of respondents with tertiary education is below average. Therefore, in Kaduna most of the respondents might provide un-skilled manpower for the few industries. This is also reflected in the monthly earning because majority of the respondents in the cities having high percentage of respondents with tertiary education level earned above ₦40,000 per month, except in Ibadan where their income was between ₦20,000 - ₦40,000. These monthly earnings do not compare with earning of respondents in Kaduna that was below ₦11, 000. The higher the income, the higher the expendable money and the more meat product that will be consumed.

Most of the respondents in all the four cities purchased beef compared to other type of meat like chevon and poultry. The low purchase of chevon and poultry may be explained by tradeoff phenomenon. Gossard and York (2003) reported that tradeoffs are made among different types of meat, that is, increasing the consumption of one type of meat may reduce the consumption of another

type. Therefore, it can be deduced from the result of the survey that the high purchase of beef by the consumers may reduce the purchase of other meats. Furthermore, the result of this survey agrees with the report of de Almeida *et al.* (2006) on weekly consumption pattern of meat that beef accounted for 58%; chicken 30%; fish 6%; pork 5%; and mutton 1%. The report indicated that beef was highly consumed by the populace compared to other meat types.

Majority of the consumers in Abuja, Ibadan and Kaduna employed freezing as a method of preserving their meat while consumers in Lagos claimed that they preferred to roast their meat as a method of preservation. It might be assumed that consumers in Lagos city are fond of varieties which might make them prefer roasting as a mean of preservation than freezing. Consumers in Abuja are also fond of roasting their meats as a method of preservation, although the percentage is small compared to Lagos but higher compared to either Ibadan or Kaduna cities. This might be probably due to the fact that consumers in these two cities are engaged in white collar jobs which make them to be extremely busy and out of their homes for long hours during the day and it is assumed that roasting their meat will lessen the stress of preparing the meat whenever they want to consume it. From the survey, it was revealed that most consumers in Kaduna city also employed drying as a method of preservation, probably because of the high ambient temperature (about 36-38°C) and high wind speed in the Northern Guinea savanna ecological zone that Kaduna is located.

The higher percentage of respondents purchasing processed meat in Abuja and Lagos could be attributed to the fact that in these cities most of the respondents earn above ₦40,000 per month, indicating that there will be capital for the purchase of luxuries and this agrees with the report of (Bourdieu, 1984) that variation in consumption patterns may be expected among individuals in different social categories and that differences in food consumption patterns may distinguish one social group from another. The high percentage of consumers obtained in Kaduna could be due to high prevalence of meat animals in the environment, which is one of the characteristics of the northern cities, being in the savanna ecological zone with animal grazing as an outstanding land use. These meats could be processed into different kinds of meat products, either to preserve and/or to add values. The processing and high prevalence of meat animals may account for the presence of varieties of meat products in Kaduna. According to Jimnez-Colmenero *et al.* (2001) consumption of meat and meat products is affected by various factors such as product characteristics, the consumer (in terms of economic status) and environmental related factors. This result also agrees with the report from the study carried out by Gossard and York (2003) that differences in meat consumption could simply be

explained by the availability and price of meat in different locations, or they could reflect regional cultural differences.

Most consumers in Abuja, Ibadan and Kaduna preferred to purchase *Suya* than any other meat product, while consumers in Lagos preferred the purchase of *Kilishi*. The preference for *Kilishi* over *suya* by Lagos respondents may be explained by the pleasure they derive in varieties, *suya* being a common meat product that is available in most places within the country. Considering the purchase of other meat products, Lagos residents are the least purchaser of roasted chicken. This may be attributed to the familiarity with taste of roasted meat because roasting is a method most of the respondents engaged in when preserving their meat at home.

Respondents in Abuja and Kaduna claimed that they are very familiar with meat floss compared to Ibadan and Lagos. The high percentage of respondents observed in Abuja and Kaduna could be attributed to the fact that this product is popular in the Northern cities (Ogunsola and Omojola, 2008), and these two cities are located in the Northern part of the countries. This pattern is also noticed in the respondents' consumption pattern of meat floss, with respondents in Lagos city having the lowest consumption rate. Familiarity and availability of product in the environment might best explain the high consumption rate of meat floss by Abuja and Kaduna respondents. Although the frequency in the consumption pattern of meat floss is low in all the cities because the survey results was below 40% but generally, respondents in Abuja and Kaduna still consumed the product more frequently than respondent in Lagos.

The respondents in the cities located in Southern Nigeria (Ibadan and Lagos) claimed that they first came in contact with meat floss at a party (with the highest percentage from Lagos), unlike respondents in Kaduna who claimed that the product is readily available at market places, shops and motor parks.

To all the consumers, the price of meat floss is fair and affordable. The affordability may be due to the fact that Kaduna respondents see meat floss as any other meat products, while that of Lagos can be attributed to the fact that the inhabitants are in affluence and can pay more for any product they desire. Jimnez-Colmenero *et al.* (2001) reported that one of the factors that influence the purchase of meat products is the economic status of the consumers. The fairness of the price of meat floss to Abuja respondents may be attributed to the high income claimed by most respondents and the ready availability of the product on request.

Majority of consumer respondents in all the four cities have little concern about the type of meat or spices being used in the production of meat floss, but greatly concerned about the packaging and hygiene of the product. The low standard of hygiene perceived or the great concern the consumers have towards the packaging method or hygiene condition of the product could probably be as a result of the low level of education of the producers. Most of the producers have secondary school certificates as reflected in the survey carried out. According to Skandamis and Nychas (2002), packaging is an indispensable element in the food processing industry as it ensures that better quality products reaches the consumers and makes the foods easy to be handled and stored by retailers and consumers.

The survey of consumers also revealed that meat floss is readily available in Abuja and Kaduna. This may be explained by availability of meat animals and familiarity of northern savanna dwellers with the various meat products, the two cities being located in northern axis of the country. This agrees with the report of Gossard and York (2003) that availability of a product will determine the consumption level of such product.

Chapter Four

4.0 Qualitative evaluation of meat floss prepared from different meat types

4.1 Introduction

Product development and innovation are necessary to offset the growth in the availability of food products competing for disposable income and the red meat industry is in a mature stage, where product development and innovation is necessary to bring about significant growth (Resurrecion, 2003).

Meat is a complex food with a highly structured nutritional composition. It becomes edible and more digestible when it is subjected to cooking. However, heat treatment can lead to undesirable modifications, such as the loss of the nutritional value due to lipid oxidation, and changes in the protein fraction (Rodriguez-Estrada *et al.*, 1997) and as reported by Huda *et al.* (2010) that different types of meat used for sausage raw material may yield different quality characteristics in the sausages. Furthermore, during the past decade, restructured meat products have been produced from specific part of meats such as breast and thigh (Huda *et al.*, 2011) Breast part is usually used in meat product formulation due to its physical superiority characteristics such as its uniformity, soft texture, and lighter color but thigh meat with its higher fat content will give stronger flavor when it is cooked, and finally attracts the consumer preferences (Huda *et al.*, 2011) and use of thigh meat in meat product formulation will minimize the production cost (Petracci *et al.*, 2008) hence, there is need for studies on the nutrition and qualities of different meat products from different meat types (Ikhlas *et al.*, 2011).

Meat floss (Danbunama) is an intermediate moisture meat product that is prepared essentially from beef. The ability of the product to keep for several days at room temperature is fast making the product a house name. However, with increasing awareness and consumption of meat floss, coupled with the high price of the product as a result of the high price of beef especially the choice part (the thigh muscle), it therefore, becomes necessary to produce meat floss from other meat types. This study was therefore designed to evaluate the nutritive and eating qualities of meat floss and also assess the keeping quality of the products when prepared from different meat types.

4.2 Materials and methods

4.2.1 Sample Collection and Experimental design

The meats used for this study were the semi-tendinosus of matured bull, goat and pig. These were purchased from a commercial abattoir, Bodija in Ibadan Oyo State. The muscles were excised from the carcass of singed animals within one hour postmortem. The design of the experiment was completely randomized design (CRD) with each meat type representing a treatment. Each treatment was replicated three times.

4.2.2 Production of meat floss

The flow chart of the preparation of meat floss is presented in Figure (8). It includes spice mixture preparation, meat preparation, cooking, shredding, frying, de-oiling (draining of excess oil) and packaging. All the steps involved in meat floss production in this study were carried out in the Meat Science Laboratory in the Department of Animal Science University of Ibadan, Oyo State.

4.2.2.1 Meat preparation

The meats were trimmed off of all visible dirt, fats, connective tissues and ligaments and washed with cool clean water. They were cut into chunks of average weight of 100 g each. Thirty (30) chunks were randomly selected per meat type to have three (3) kg of fresh meat for respective meat type.

4.2.2.2 Preparation of Spice mixtures

Two spice mixtures were formulated as shown in Tables 8 and 9. The spice mixtures were cooking recipe (Table 8) and shredding recipe (Table 9). The spice mixtures were formulated on the basis of several trials conducted among the scientists and students of the Department of Animal Science, University of Ibadan. The ingredients used in this formulation were purchased from a local market. After removal of extraneous matters, all spices were dried in an oven 60°C for 3 hrs. However, garlic had been cut into small pieces and spread on a tray to air-dry at room temperature (28°C) for three weeks in the laboratory. Each of the spices was then ground separately in a grinder (model BLSTMG. PN. 133093-002) to powder. The coarse particles were removed using a sieve of 1.0 mm mesh diameter. The fine powder of each spice was measured as required for each of the

two recipes and mixed thoroughly. The cooking recipe and the shredding recipe were separately stored in airtight plastic container for subsequent use.

4.2.2.3 Cooking

Each meat type was put into a pot and placed on an adjustable Pifco Japan Electric Hot Plate (Model Number ECP 2002) for cooking and the cooking recipe was added in the ratio of 1 g of spice to 100 g of meat. Thirty (30) g of the cooking spice was added to cook each meat type. Four (4) medium-sized (500 g) of onions (approximately 50 g of onions on dry matter basis) were thinly sliced and added. Water was added at the ratio of 1.5 litres to 1.0 kg of meat, thus cooking each meat type with 4.5 litres of water. This was cooked to an internal temperature of 72°C.

After the meat has been properly cooked, the broth was allowed to dry with the meat. The meat samples were removed from the pots, spread on a tray equilibrate to room temperature and weighed.

4.2.2.4 Shredding

The cooked and cooled meat samples were shredded separately by pounding with a local mortar and pestle. The shredding recipe was added in the ratio of 1:20 i.e. 50g of spice to 1000g of meat while for onion, 120g was added to every 100g of spice used. These were weighed and added a little at a time as pounding progressed for uniform mixing of the recipe. The pounding was intense and consistent until the meat strands disengaged and were beaten to shreds.

4.2.2.5 Frying

The shredded meat from each meat type was separately deep fried in soya bean oil (grand®) which was pre heated to 180°C (the ratio of oil to meat was 1 litre to 500g of meat). The meat samples were fried at 70 strokes per minute for about 20 minutes (until a golden brown colouration was obtained).

4.2.2.6 Draining of excess oil

After frying each batch of the shredded meat until golden brown colouration was obtained, the products were poured into a colander and pressure applied. This was done to remove excess oil thereby preventing the final product from sticking together, leaving a dry spongy

product. The meat floss from each meat type were poured into separately marked trays, allowed to cool and separate into strands.

4.2.2.7 Packaging

Three types of packaging materials were used in this study they include: Arcylic bottles, Polyethylene and Polyamide. These were purchased in a commercial market (Bodija) in Ibadan Oyo State. Meat floss obtained from the different meat types were packaged into these three packaging media for three weeks (for preservation purpose) and further analysis.

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Fresh meat (excised within 1 hr post mortem from the hind portion of carcass)

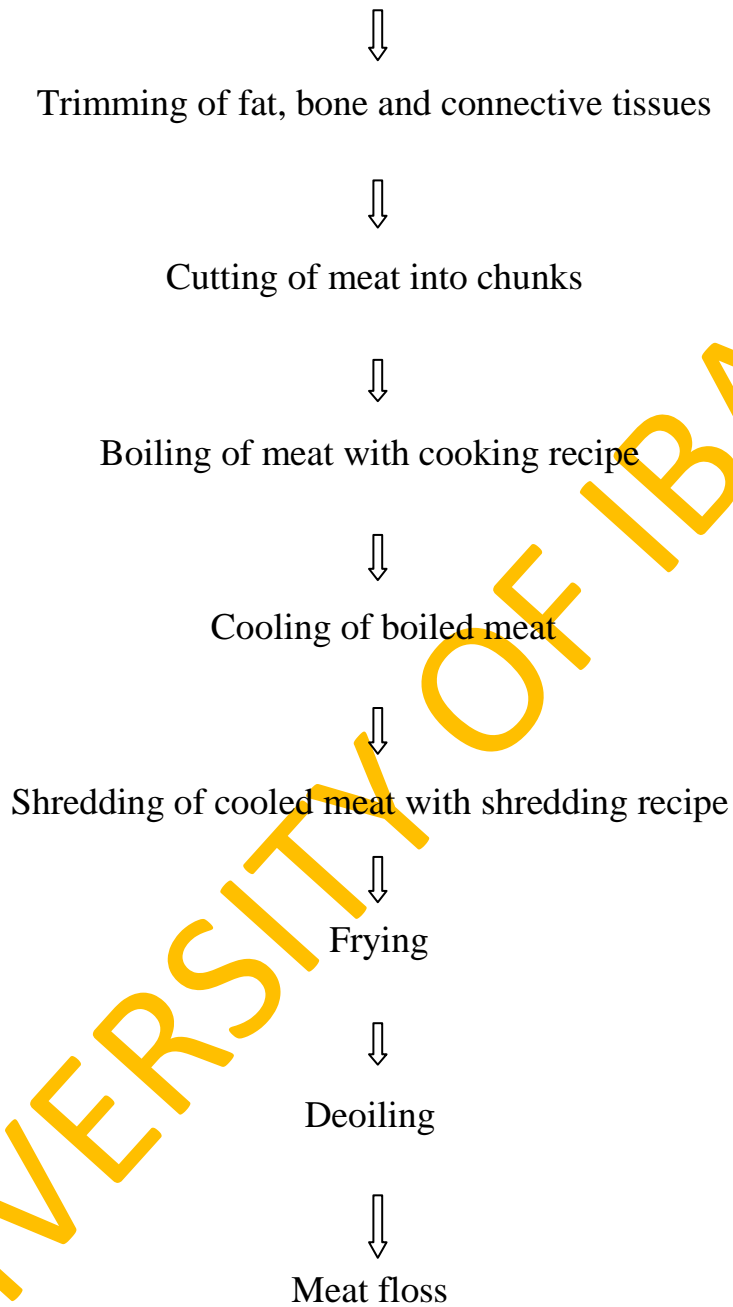


Figure 8. **Production Flow Chart of Meat floss**

Table 8: Composition of cooking recipe used for meat floss production (g/100g)

Ingredients /seasoning	Scientific/Botanical names	Quantity (g/100g)
Salt	Sodium Chloride	10.00
Maggi (Knorrs®)	Maggi	15.00
Thyme	<i>Thymus vulgaris</i> L.	12.50
Curry	<i>Murraya koenigii</i> (L.) Spreng.	12.50
Onions	<i>Allium cepa</i> L. var. <i>cepa</i>	50.00
Total		100.00

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Table 9: Composition of shredding recipe used for meat floss production (g/100g)

Ingredients /seasoning	Scientific/*Botanical names	Quantity (g/100g)
Red Pepper	<i>Piper nigrum</i> L.	35.00
Maggi (Knorr®)	Maggi	30.00
African Nut Meg	<i>Monodora myristica</i> (Gaertn.) Dunal	2.50
Ginger	<i>Zingiber officinale</i> Rosc.	4.00
Garlic	<i>Allium sativum</i> L.	3.00
Cloves	<i>Syzygium aromaticum</i> (L.) Merr. et L.M. Perry	2.50
Curry powder	<i>Murraya koenigii</i> L.	3.50
Thyme leaves	<i>Thymus vulgaris</i> L.	2.50
Salt	Sodium Chloride	5.00
Onions	<i>Allium cepa</i> L. var. <i>cepa</i>	12.00
Total		100.00

* Botanical names according to Rehm and Espig (1991)

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4.3 Parameters Measured

4.3.1 Meat Quality Studies

The meat quality studied included cooking loss, thermal shortening, water holding capacity, sensory evaluation and proximate analysis. All the meat quality studies were carried out in the Meat Science Laboratory in the Department of Animal Science University of Ibadan, Oyo State.

4.3.1.1 Cooking loss

Cooking loss was measured by weighing approximately 10 g meat samples, wrapped loosely in polyethylene bags and cooked in a pre-heated water for 20 minutes on an adjustable Pifco Japan Electric Hot Plate (Model No. ECP 2002) until the geometric centre of meat samples was heated to 72°C (Malgorzata *et al.*, 2005). Meat samples were removed and allowed to equilibrate to room temperature. The meat samples were reweighed and cooking loss calculated as:

$$\text{Cooking loss \%} = \frac{\text{Initial weight of meat} - \text{Final weight of meat}}{\text{Initial weight of meat}} \times 100$$

4.3.1.2 Thermal shortening

Thermal shortening was determined by subjecting meat samples of known length and thickness to moist heat cookery for 20 minutes in a pre-heated water. The lengths of meat samples were re-measured after cooking for 20 minutes and equilibrating to room temperature. The difference in lengths was expressed as thermal shortening following the modified method of Mahendrakar *et al.* (1988).

$$\text{Thus: Thermal shortening \%} = \frac{\text{Initial length of meat} - \text{Final length of meat}}{\text{Initial length of meat}} \times 100$$

4.3.1.3 Water Holding Capacity

Water Holding Capacity (WHC) of meat samples was determined by the press method as slightly modified by Suzuki *et al.* (1991). An approximately 1g of meat sample was placed between two (9 cm Whatman No1) filter papers (Model C, Caver Inc, Wabash, USA). The meat sample was then pressed between two 10.2 X 10.2 cm² plexi glasses at about 35.2 kg/cm³ absolute pressure for 1 minute using a vice. The meat samples were removed and oven dried at 80°C for 24 hours to determine the moisture content. The amount of water released from the meat samples was measured indirectly by measuring the area of filter paper wetted relative to the area of pressed meat samples. Thus, the water holding capacity was calculated as follows:

$$\text{WHC} = 100 - \frac{\{ (A_r - A_m \times 9.47) \}}{W_m - W_o}$$

Where: A_w = Area of water released from meat samples (cm²)

A_m = Area of meat samples (cm²)

W_m = Weight of meat samples (g)

M_o = Moisture content of meat samples (%)

9.47 = a constant factor

4.3.2 Evaluation of meat floss

4.3.2.1 Product yield

The product yield of meat floss was calculated using the method described by Kembi and Okubanjo (2002). It was expressed as the ratio of the final weight of the product (meat floss) to the initial fresh meat samples.

$$\text{Product Yield (\%)} = \frac{\text{Weight of meat floss}}{\text{Weight of raw meat sample}} \times 100$$

4.3.2.2 Sensory Evaluation

The panelist at each stage consisted of 25 member semi-trained panel according to the procedures of AMSA (1995). They comprised of both male and female pooled, from the

postgraduate students and staff population within the Department of Animal Science, University of Ibadan. They ranged between 26-40 years of age. They were provided with unsalted cracker biscuits and water for use in-between treatment meat samples. The meat floss from different meat types were presented sequentially to the panellists on a clean saucer. Meat floss from each treatment was evaluated independent of the other. The panelists rated the meat samples on a 9-point hedonic scale for colour, flavour, tenderness, roppiness, juiciness, texture and overall acceptability. The hedonic scale for sensory evaluation for this study is shown in appendix III.

4.3.2.3 Proximate analysis

Proximate analyses were carried out on the raw meat samples and freshly prepared meat floss according to the method described by AOAC (2000). Parameters analyzed for included moisture content, crude protein, ether extract and ash contents.

4.3.2.4 Thiobarbituric Acid reactive Substances (TBARS)

This was carried out at the Koab analysis Trans Amusement Park Ibadan, Oyo state. The distillation method developed by Tarladgis *et al.* (1964) was used with some modifications (Kubow 1992; Torres and Okani, 1997). Ten (10) g of sample and 50 ml of distilled water were put in a beaker and homogenized for two minutes. The homogenate was transferred to a Kjeldahl flask. Subsequently, 47.5 ml of distilled water, 2.5 ml of HCl (4 mol/l), some anti-foaming drops, some glass beads, and 2 ml sulfanilamide solution (0.5% in 20% HCl solution) are added. The mixture was then distilled under intensive heating until 50 ml of distillate was collected in an Ernlemeyer flask. The flask was agitated. 5 ml aliquots are then withdrawn and transferred to test tubes to which 5 ml of 2-TBA solution (0.02 mol/l) were further added. The test tubes were closed and heated in a water bath at 96°C for 35 min. After cooling, absorbance at 532 nm is read using an UV-vis spectrophotometer (CE1020 model, Cecil – UK). The results were expressed as mg malonaldehyde (MDA)/kg products.

4.3.2.5 Microbial Plate Counts

This was carried out at the Department of Microbiology, University of Ibadan, Oyo State. Meat floss samples (10g) were blended with 90 ml of 0.1% (W/V) peptone water for 60 sec using a blender with plate 5 mm (model 242 Nakai, Japan). Additional dilutions were made in

0.1% peptone water (W/V). 1ml of undiluted homogenate of each sample was spread on duplicate Petri plates. Bacteria numbers were determined from plates bearing colonies. Counts were obtained with aerobic plate counts on plate count Agar (DIFCO, USA) incubated at 32°C for 48 hours.

All analyses were done following the procedures described by ICMSF (1986), APHA, (1992) and AOAC, (2000) and all analyses were carried out in triplicates.

4.4 Statistical analysis

All data obtained were subjected to statistical analysis using SAS 2000 package while means were separated with Duncan Multiple Range Test. Statistical significance was set at $P < 0.05$.

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4.5 Results

4.5.1. Proximate composition of raw meat types

The proximate composition of raw meat types used in meat floss production is shown in Table 11. There were no significant difference ($P>0.05$) between the moisture contents of chevon (66.70%) and pork (64.16%), but these were significantly less ($P<0.05$) than 71.98% of beef.

The crude protein contents of the meat types that ranged between 21.23 and 22.89 % were not significantly ($P>0.05$) different. The ash content of beef (1.52%) and chevon (1.60%) were significantly lower ($P<0.05$) than that of pork (1.14%).

The ether extract content of the meat ranged between 1.64% and 3.37% with chevon having the least values and pork the highest value.

4.5.2. Physical Properties of Meat

The results obtained on the physical properties of meat used in the production of meat floss are shown on Table 10. The result showed that the cooking losses of the meats were not significantly different ($P>0.05$), although numerically, pork had the highest cook out (39.73%) followed by chevon (38.79%) and beef (38.78%). The thermal shortening of chevon (28.34%) was significantly higher ($P<0.05$) than that of beef (22.15%) and pork (22.26%). Chevon gave the highest ($P<0.05$) water holding capacity (69.44%) followed by beef (67.70%) while pork gave the least (62.82%).

4.5.3 Meat Yield and oil absorption

Information on Table 12 showed the product yield and volume of oil absorbed by the different meat types during meat floss production. The result showed that the product yield of chevon (74.05 g/100g) was significantly higher ($P<0.05$) than that of beef (70.07 g/100g) and pork (68.88 g/100g).

There were no significant differences ($P>0.05$) between the quantity or percentage of oil absorbed by pork (15.44) and by beef (17.75) during production but the two were significantly low ($P<0.05$) compared to the quantity absorbed by chevon (22.75).

Table 10: Physical properties of meat types used in meat floss production

Parameters	Beef	Chevon	Pork
Cooking loss (%)	38.78± 0.75	38.79±1.69	39.73± 0.43
Thermal shortening (%)	22.15±1.95 ^b	28.34± 1.45 ^a	22.26± 1.09 ^b
Water holding capacity (%)	67.70± 0.76 ^b	69.44± 0.46 ^a	62.82± 0.44 ^c

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

Table 11: Proximate composition of raw meat types used in meat floss production

Parameters	Beef	Chevon	Pork
Moisture content (%)	71.98±0.54 ^a	66.70±0.32 ^{ab}	64.16±0.32 ^b
Crude protein (%)	22.89±1.10	21.23±0.85	22.66±0.72
Ash (%)	1.52±0.02 ^a	1.60±0.12 ^a	1.14±0.02 ^b
Ether extract (%)	1.81±0.12 ^b	1.64±0.01 ^b	3.37±0.06 ^a

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

Table 12: Product yield and Volume of oil absorbed by different meat types during meat floss production

Parameters	Beef	Chevon	Pork
Yield (g/100g)	70.07± 0.80 ^b	74.05± 1.33 ^a	68.88±5.48 ^b
Oil absorbed (%)	17.75± 3.89 ^b	22.75± 3.88 ^a	15.44± 0.62 ^b

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

4.5.4 Proximate composition of meat Floss products

The proximate composition of meat floss prepared from different meat types is as shown in Table (13). The result showed that there was no significant difference ($P>0.05$) in the moisture contents of pork floss (19.59%) and chevon floss (19.29%), but these two were significantly higher ($P<0.05$) than 17.69% contained in beef.

The protein contents of the meat floss differed significantly ($P<0.05$) from each other and they were 39.75% in beef floss, followed by 41.78% in pork floss and 46.73% in chevon floss. The result also indicated that there was no significant difference ($P>0.05$) in the ash contents of chevon floss (3.11%) and pork floss (2.68%), but these were significantly higher ($P<0.05$) than 1.79% obtained for beef floss. The least ether extract content (2.30%) was obtained in chevon, followed by 3.12% in beef floss and 3.95% in pork floss.

4.5.5 Organoleptic characteristics of meat Floss products

The organoleptic characteristics of meat floss prepared from different meat types are as shown in Table 14. There were no significant difference ($P>0.05$) in the aroma of all the products and the values ranged from 3.55 to 4.22. Pork floss had highest values in terms of aroma, flavour, tenderness, juiciness and texture compared to that of chevon floss and beef floss. There was no significant difference ($P>0.05$) between beef floss and chevon floss for aroma, tenderness, juiciness and texture. The result obtained showed that roppiness was adjudged similar ($P>0.05$) for the meat floss from the three meat samples while the panelist gave higher score (7.44) to beef meat floss, 6.56 to chevon meat floss and 6.22 to pork meat floss in terms of overall acceptability.

4.5.6 TBARS and microbiological counts (Total Plate Counts) values of freshly prepared meat floss

The TBARS was least in freshly prepared pork (1.30mg/100g) and highest in beef floss (2.40mg/100g). The microbiological plate counts was highest ($P<0.05$) $3.97 \log_{10}^{-2}$ cfu/g/cm² followed by that of pork floss ($3.60 \log_{10}^{-2}$ cfu/g/cm²) and least in beef floss ($2.13 \log_{10}^{-2}$ cfu/g/cm²).

Table 13: Proximate composition of meat floss prepared from different meat types

Parameters	Beef	Chevon	Pork
Moisture content (%)	17.69±0.68 ^b	19.29±0.60 ^a	19.59±1.01 ^a
Crude protein (%)	39.75±0.38 ^c	46.73±0.51 ^a	41.78±0.48 ^b
Ash (%)	1.79±0.08 ^b	3.11±0.17 ^a	2.68±0.34 ^a
Ether extract (%)	3.12±0.18 ^b	2.30±0.34 ^c	3.95±0.15 ^a

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

Table 14: Sensory evaluation of meat floss prepared from different meat types

Organoleptic properties	Beef	Chevon	Pork
Aroma	3.55± 1.59 ^b	3.56± 1.81 ^b	4.22±1.48 ^a
Flavor	5.11±1.69 ^b	6.00± 1.23 ^a	6.33±1.13 ^a
Tenderness	6.89± 1.73 ^b	6.44± 2.22 ^b	7.22±1.85 ^a
Juiciness	5.56± 1.95 ^b	6.22± 1.64 ^{ab}	7.33±0.87 ^a
Texture	5.56± 1.51 ^b	5.33± 2.18 ^b	6.89±1.69 ^a
Roppiness	5.22± 1.51	5.00± 2.18	5.50±1.69
Overall Acceptability	7.44± 0.88 ^a	6.56± 1.13 ^b	6.22±1.72 ^b

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

Table 15: TBARS (mg/100g) and microbiological counts \log_{10}^{-2} cfu/g/cm² values of freshly prepared meat floss from different meat types

Parameters	Floss Type		
	Beef	Chevon	Pork
TBARS (mg/100g)	2.40±0.10 ^a	2.00±0.20 ^{ab}	1.30±0.10 ^b
Microbiological Count (\log_{10}^{-2} cfu/g/cm ²)	2.13±0.09 ^b	3.97±0.18 ^a	3.60±0.23 ^a

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

4.5.7 Thiobarbituric acid reactive substances (TBARS) of stored meat floss products

The thiobarbituric acid reactive substances (TBARS) of the product differently packaged for 7, 14 and 21 days are presented in Tables 16. The result revealed that except for beef floss on the 7th day of storage that has a TBARS value of 1.74mg/100g. The TBARS of beef floss and chevon floss were statistically similar. The same trend observed in day 7 of storage was also observed at days 14 and 21 of storage respectively. At all the storage periods and irrespective of the storage media, pork floss gave the least ($P < 0.05$) TBARS value.

When the products were stored in Acrylic bottles, the TBARS of chevon and pork were similar of days 14 and 21 of storage while those of beef floss were the same ($P > 0.05$) for days 7 and 14 of storage (1.74 and 1.87mg/100g) respectively. However, the TBARS of the products when stored in polyethylene were similar in days 14 and 21 of storage ($P > 0.05$) irrespective of the meat type used while at days 7 and 21 of storage, beef floss had TBARS that were statistically similar ($P > 0.05$).

The TBARS of beef floss stored in polyamide ranged between 2.33 - 2.39mg/100g at days 7 to 14 days of storage while those of chevon and pork floss ranged from 2.22 – 2.31mg/100g and 1.87 – 1.90mg/100g respectively for similar storage period. However, irrespective of the storage period and meat floss type, none of the TBARS value was significantly different ($P > 0.05$).

The TBARS levels of meat floss inside different packaging media is shown on Table 17. TBARS of chevon floss stored in Acrylic bottle was higher than those of beef floss and pork floss stored in the same media. The same trend was observed when the products were stored in polyethylene. However, when the products were stored in polyamide, beef floss had the highest TBARS value (2.36mg/100g), followed by chevon floss 2.27mg/100g and pork floss 1.94mg/100g. Beef floss stored in polyethylene and polyamide gave TBARS values that were similar 2.34 and 2.36mg/100g respectively while the one stored in Acrylic bottle was the least 1.84mg/100g. All samples stored in acrylic bottles had the least TBARS values in comparison to those stored in polyethylene and polyamide containers.

Table 16: TBAR substances (mg/100g) of meat floss from different meat types and differently packaged for 7, 14 and 21 days. Values are mean±SD (n=3).

Packaging Media	Meat Types	Storage Time (Days)		
		7	14	21
Acrylic bottle	Beef	1.74±0.22 ^{by}	1.87±0.03 ^{by}	1.92±0.03 ^{ay}
	Chevon	1.89±0.01 ^{bx}	2.27±0.02 ^{ax}	2.33±0.08 ^{ax}
	Pork	1.23±0.03 ^{bz}	1.44±0.01 ^{az}	1.48±0.02 ^{az}
Polyethylene	Beef	2.26±0.04 ^x	2.37±0.09 ^x	2.39±0.01 ^x
	Chevon	2.44±0.05 ^{bx}	2.67±0.01 ^{ax}	2.75±0.03 ^{ax}
	Pork	1.56±0.01 ^{by}	1.71±0.01 ^{ay}	1.67±0.01 ^{ay}
Polyamide	Beef	2.33±0.11 ^x	2.39±0.06 ^x	2.37±0.06 ^x
	Chevon	2.22±0.02 ^x	2.29±0.01 ^x	2.31±0.09 ^x
	Pork	1.87±0.03 ^y	1.96±0.01 ^y	1.98±0.01 ^y

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

4.5.8 Microbiology counts of meat floss from different meat types as affected by storage period.

Shown on Table 18 is the result of microbial load count of meat floss from different meat types differently packaged and stored for 7, 14 and 21 days. Generally, the microbial load of the meat floss irrespective of the packaging media increased until the 14th day when it started to decrease. It was also observed that irrespective of the days of storage or packaging media, chevon floss had significantly higher ($P<0.05$) microbial load than either beef floss or pork floss .

The microbial load of meat floss inside polyamide on each of the days of storage were significantly higher ($P<0.05$) than those of acrylic bottle and polyethylene. The microbes recorded at 21st day in each of the packaging media were significantly lower ($P<0.05$) than the number of microbes found on the 7th day. There was a deviation from this trend in the polyamide packaging media, where the microbial load recorded on the 21st day was significantly higher ($P<0.05$) than the value recorded on the 7th day.

Displayed on Table 19 is the microbial load of different meat floss inside different packaging media. The result revealed that no significant difference existed ($P>0.05$) among the microbial loads of the meat floss inside the acrylic bottles. The microbial loads of chevon floss inside the polyethylene and polyamide storage media were significantly higher ($P<0.05$) than those recorded for beef floss and pork floss.

Irrespective of the type of meat floss, the microbial load found in polyamide was significantly higher ($P<0.05$) than those recorded inside acrylic bottle or polyethylene.

Table 17: TBAR substances (mg/100g) of meat floss from different meat types and differently packaged. Values are mean±SD (n=9).

Packaging Media	Meat Types			Packaging Mean
	Beef	Chevon	Pork	
Acrylic Bottle	1.84±0.14 ^{by}	2.16±0.21 ^{ay}	1.38±0.12 ^{cz}	1.79
Polyethylene	2.34±0.08 ^{bx}	2.62±0.14 ^{ax}	1.65±0.07 ^{cy}	2.20
Polyamide	2.36±0.07 ^{ax}	2.27±0.06 ^{by}	1.94±0.05 ^{cx}	2.19
Meat Type Mean	2.18	2.35	1.66	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

Table 18: Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of meat floss from different meat types and differently packaged for 7, 14 and 21 days. Values are mean±SD (n=3).

Packaging Media	Meat Types	Storage Time (Days)		
		7	14	21
Acrylic bottle	Beef	3.80±0.17 ^{by}	8.67±0.12 ^{ax}	3.57±0.08 ^{by}
	Chevon	3.80±0.14 ^{cy}	7.60±0.25 ^{ay}	4.86±0.15 ^{bx}
	Pork	5.60±0.26 ^{bx}	7.40±0.22 ^{ay}	2.83±0.06 ^{cz}
Polyethylene	Beef	4.27±0.16 ^{bx}	5.60±0.10 ^{ay}	3.50±0.13 ^{cy}
	Chevon	4.50±0.14 ^{cx}	7.40±0.13 ^{ax}	6.40±0.19 ^{bx}
	Pork	3.30±0.12 ^{by}	7.20±0.23 ^{ax}	1.87±0.13 ^{cz}
Polyamide	Beef	6.13±0.27 ^{bx}	9.33±0.21 ^{ay}	4.17±0.13 ^{cz}
	Chevon	5.50±0.06 ^{cy}	11.20±0.19 ^{ax}	8.50±0.10 ^{bx}
	Pork	3.30±0.34 ^{cz}	8.30±0.23 ^{az}	6.60±0.18 ^{ay}

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

Table 19: Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of meat floss from different meat types and differently packaged. Values are mean \pm SD (n=9).

Packaging Media	Meat Types			Packaging mean
	Beef	Chevon	Pork	
Acrylic Bottle	5.35 \pm 2.50 ^y	5.93 \pm 1.69 ^y	5.28 \pm 2.00 ^y	5.52
Polyethylene	4.46 \pm 0.93 ^{by}	5.59 \pm 1.37 ^{ay}	4.12 \pm 2.39 ^{by}	4.72
Polyamide	6.54 \pm 2.26 ^{bx}	8.40 \pm 2.47 ^{ax}	6.07 \pm 2.21 ^{bx}	7.00
Meat Type Mean	5.45	6.64	5.16	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

4.6 Discussion

The cooking loss is a combination of liquid and soluble matter which are lost from the meat during cooking. At increasing temperatures the water content of the meat has been shown to decrease, while the fat and protein content increase indicating that the main part of the cooking loss is water (Heymann *et al.*, 1990). Loss of water from meat is due to the effect of heat, which induced protein denaturation during cooking and causes less water to be entrapped within the protein structures which are held by capillary forces. Okubanjo *et al.* (2003) concluded that water loss is of economic concern because it affects weight loss along the distribution chain during cooking. Cooking loss depends on the raw meat quality. Asalyng *et al.* (2002) reported that raw meat quality influenced the cooking loss at a certain temperature. Meat with high cooking loss will have low water holding capacity. Cooking loss is of interest to the meat processor because it is expected to explain in part the variations in juiciness, which also influences the appearance of the meat after processing. Hence, cooking loss will affect the optimal eating quality and is of great importance to the catering industry (Fakolade, 2008).

The cooking losses of the different meat were similar to each other ($P > 0.05$). The cooking loss obtained for chevon (38.79%) in this study is similar to 38.72% obtained by Mohammad *et al.* (2010) for meat from young goats and higher than 35.77% and 33.40% obtained by the same researcher for meat from older goats. This result was also higher than 34.20% cooking loss obtained by Elkhidir *et al.* (1998) for goats. The cooking loss obtained for pork in this study is higher than 27.82% obtained by Hodgson *et al.* (1991).

It was noticed that chevon had higher degree of shortening during cooking, which might be due to the presence of high collagen. Casey (1992) reported that collagens are susceptible to shrinkage during cooking. Degree of shortening is also determined by water loss. Chevon was observed to have a high ability of retaining its intrinsic water during cooking which corroborates the report of Karakaya *et al.* (2006) that goat meat and mutton have higher water holding capacity in both pre and post rigor states. This also agrees with the report of Babbitker *et al.* (1990) that chevon had lower cooking loss than lamb due to its superior water holding capacity. The values obtained in this study are higher than the values (61.77% to 63.36%) obtained for goats of different ages by Mohammad *et al.* (2010). It should be noted that meat

with higher water holding capacity is more desired because it will result in a higher product yield.

The crude protein obtained for beef, chevon and pork in this study are slightly lower than 25%, 23% and 25% obtained by USDA (2001) for beef, chevon and pork respectively. The values obtained for crude protein and ash contents of beef in this study are higher than the range (18.86-19.15%) and (0.95-0.98%) obtained for crude protein and ash contents respectively by Akhter *et al.* (2009). However, the ether extract (1.86-1.98%) and moisture (76.28-77%) contents obtained by these same authors were higher than values obtained for beef in this study. Also, the ether extract value (1.17%) obtained for beef by Lapital *et al.* (2004) was less than the value obtained in this study. The protein content of chevon obtained was higher than 19.47% and 19.89% while the moisture content was lower than 76.62% and 76.37% obtained for goat kids fed different diets by Adam *et al.* (2010). However, the values obtained for crude protein and ash for chevon in this study are higher than 19.48-20.86%; 1.00-1.08% for crude protein and ash reported respectively obtained by Silva *et al.* (2011) for goat fed different levels of licury oil in the diet. It was noticed that chevon had the highest ash content compared to either beef or pork and this agrees with the report of Casey (1992) that chevon meat are rich in potassium compared to either beef or pork.

The high nutritional properties obtained for chevon in this study corroborates the reports of Adam *et al.* (2010) that goat meat is higher in quality than sheep or cattle meat. Gadiyaram and Kannan (2004) also reported that chevon is a good source of red meat for the production of further-processed meat foods because of its superior water-holding capacity and nutritional properties. The protein content of (22.66%) obtained for pork in this study is higher than 20.15% obtained by Hodgson *et al.* (1991). However, the moisture and ether extract contents were lower than those reported by the same author while the ash content was higher than 1.00% (Moss *et al.*, 1983). The variation noticed in the chemical compositions of the meat types could be influenced by different factors such as species, breed, age, anatomical location of muscle and nutrition (Lawrie, 1998).

There were noticeable increases in the nutrient profiles of the products. For instance, the percentage increase in the nutrient profile were 74%, 120%, 84% for crude protein, 18%, 94%, 135% for ash contents, 72%, 34%, 17% for ether extracts for beef floss, chevon floss and pork

floss respectively. These indicate that meat floss is a nutrient dense product. The crude protein, ash and ether extract contents of the products were probably a reflection of what was in their corresponding raw meat with the raw meat with highest crude protein producing highest crude protein after processing. The result obtained for the products in this study also agrees with the report of Addrizo (1999) that roasted chevon had lower calories, fat, and saturated fat, but higher protein and iron than roasted beef, pork and lamb. Significant differences existed among the crude protein of the products and this follows the report of Gadiyaram and Kannan (2004) when beef, chevon and pork were used to make sausages and similar protein contents were observed in their products. The fat contents of meat floss in this study followed the trend observed in the sausages made with these three types of meat. Gadiyaram and Kannan (2004) reported that the fat content of chevon sausage was lower than beef or pork sausages, similar trend was observed in this study. This might be due to the fact that pork initially had a higher fat content than beef and during the process of frying a substance with initial high fat absorbed less fat from the frying medium and vice versa as reported by Fillion and Henry (1998).

The decrease in the moisture content and increase in the total fat content of the products agreed with the results of Badiani *et al.* (2002) and Kesava *et al.* (1996) who found that losses in the moisture content resulted in higher dry matter and increased content of total lipid and other components in cooked meat samples.

The moisture content of a product is one of the criteria that determine the extent of microbial spoilage of that product, because water is one of the constituents that aid bacteria growth. The more water a product contains, the more conducive the environment will be for microbial activity. The moisture contents (17.69-19.59%) of the different meat floss obtained in this study is above the range values of 8.60-13.56% obtained for different serunding (shredded meat) produced in Malaysia as reported by Huda *et al.* (2012). It is also higher than 2.8-10.3% obtained by Abubakar *et al.* (2011) for processed meats from non-ruminants which include *danbu* (shredded meat) and also lower than the values obtained by Ogunsola and Omojola (2008) for *Danbunama*. However, the protein content values obtained are higher than the range of 38.92-41.21% reported by Ogunsola and Omojola (2008) and higher than the values of 34.09-42.90% obtained for pork floss by Ockerman and Li (1999). The fat contents of the

products obtained in this study falls within the range of 3.20-31.14% obtained by Huda *et al.* (2012) for different shredded meat. The wide variation of fat contents reported in their research was attributed to the level of oil added to the product or the application of processes by the producer to remove excessive oil during serunding (meat floss) preparation. Nevertheless, the slight differences obtained in this study could be attributed to the initial fat content of the raw meats.

The yield from chevon during meat floss production was the highest compared to either beef or pork. This might be due to the fact that chevon had the highest water holding capacity in its raw state and water holding capacity and yield are directly proportional. That is, a meat with high water holding capacity is expected to have a high yield because it implies that the meat releases less of its water, resulting in less cooking loss during application of external forces such as cooking.

The most important contributing sensory attributes to eating quality are tenderness, flavour and juiciness (Safari *et al.*, 2001). Tenderness is defined as the ease of mastication, which involves initial penetration by the teeth, the breakdown of meat into fragments and the amount of residue remaining after chewing (Lawrie, 1998). It is an integrated textural property composed of mechanical, particulate and chemical components. The mechanical characteristics include hardness, cohesiveness, elasticity, grittiness and fibrousness while the chemical characteristics of meat include juiciness and oiliness (Brewer and Novakofski, 2008). Tenderness has also been shown to depend positively upon intramuscular fat (Aaslyng and Støier, 2004). Juiciness is an important factor in sensory evaluation as it facilitates the chewing process as well as brings the flavour component in contact with the taste buds (Aaslyng *et al.*, 2002). It depends on the raw meat quality and the cooking procedure (Aaslyng *et al.*, 2002). Juiciness is the feeling of moisture in the mouth during chewing. It is a dynamic attribute changing during the chewing process (Aaslyng, 2002) and positively correlated to intramuscular fat (Cummings *et al.*, 1999; Brewer *et al.*, 2001). The two sensory descriptive words for juiciness, in cooked meat, are initial and sustained juiciness (Lyon and Lyon, 1989). Initial juiciness is the amount of fluid released by the cut surface of meat, during compression between the forefinger and thumb (AMSA, 1995) and is positively correlated with the water holding capacity of meat (Offer and Trinick, 1983). Sustained juiciness is

described as the perceived juiciness after a few seconds of mastication, due to the presence of intramuscular fat stimulating saliva secretion (Lawrie, 1998).

Flavour is experienced during mastication when volatiles are released in the oral cavity. It is mainly generated during the heating process and the Maillard reactions involving reducing carbohydrates and amino acids are one of the most important routes to flavour formation (Mottram, 1991).

It would have been expected that the flavour and tenderness of beef floss should be preferred to meat floss from chevon because chevon is considered to be lower in palatability than beef, pork, or lamb (Griffin *et al.*, 1992), but from the results obtained meat floss from chevon and pork were preferred by the panelists. The preferred flavour of chevon floss could be as a result of the large volume of oil absorbed compared to beef floss because the oil is rich in polyunsaturated fatty acid.

The aroma of the products were scored low (all values were below average) probably due to the presence of garlic that has a characteristic pungent odour due to the presence of vanilloids, especially 6-gingerol (Ippoushi *et al.*, 2003). The tenderness of chevon could be attributed to the presence of zingibain in ginger (which acts as a tenderizer) which might have acted on the chevon muscle to tenderize it. It would have been expected that the juiciness of beef floss would be more preferable than chevon floss because juiciness of meat is reported to be a function of intramuscular fat content (Eikelenboom *et al.*, 1996) but the reverse was observed in this study. However, it was noticed that pork floss had higher aroma than meat floss from beef and chevon. The low aroma score for chevon meat floss agrees with the report of Casey (1992) that goat meat has a less desirable flavour, aroma tenderness and juiciness. The preference of the panelists for either pork or chevon floss could be attributed to the fact that most people are familiar with beef so they will always want to explore new products which might affect their judgment. However, despite their preferences for chevon and pork floss in most attributes of the eating qualities, beef floss was well accepted to the panelists than either chevon or pork floss which implies that people still prefer beef to any other meat.

It would have been expected that the products should be free of microorganisms when it was freshly produced because of the high temperature the products were subjected to, but analysis showed that the freshly prepared products still contained some microorganisms. The microbes

might have contaminated the product either through the environment of the processing industry, the utensils used or the personnel as reported by Cabeza *et al.* (2009).

Generally, it was noticed that as the days of storage increased, the microbial load of the products increased until at a point when they started to decrease. The increase in the microbial load could be related to the growth phase of the bacteria. During this phase, it is assumed the microbes have adjusted to their environment and there is available nutrient for them to actively grow in number by regular cell division. The later decrease in microbial load of the products as storage days increased could be attributed to the death phase of the microbes. During this phase, the rate at which the microbes die exceeds their growth rate causing a reduction in the numbers of viable cells. It is assumed that the microbes have depleted all the available nutrients that aid their growth which explains why there was reduction in the microbial load of the product at the 21st day of storage.

The high microbial load found in chevon could be attributed to its high nutrient profile (crude protein and ash content) coupled with its high moisture contents and as compared to other meat floss. Also, it is the product with initial high number of microbes. These are agents that aid the proliferation of microbes and determined the microbial load that will be found in such product at the end of storage time. An aberration to this trend was noticed in the case of pork floss and beef floss. Pork floss had a higher nutrient profile than beef floss, but the microbial load of pork floss in any of the packaging media during storage was lower than beef floss. An exception to this was noticed on the 7th day of storage where the microbial load of pork floss was higher than that of beef floss. The reason for this is not known.

It has been reported that lipid oxidation and microbial growth in meat products can be controlled or minimized by using either synthetic or natural food additives (Lee *et al.*, 1997; Mielnik, *et al.*, 2003). Also, Istrati *et al.* (2011) reported that some spices and herbs are valued for their antimicrobial activities and medicinal effects in addition to their flavor and fragrance qualities. Furthermore, many studies had reported that phenolic compounds in spices and herbs significantly contribute to their antioxidant and pharmaceutical properties (Shan, *et al.*, 2005; Wu *et al.*, 2006). Some studies claimed that the phenolic compounds present in spices and herbs might also play a major role in their antimicrobial effects (Hara-Kudo *et al.*, 2004).

The decrease in the microbial load and the slow rate of lipid oxidation of the products during storage could be attributed to the presence of antimicrobial/bacterial and antioxidant properties contained in some of the spices used. For instance, onions and garlic contain allicin which have anti microbial and antioxidant properties (Dorman and Deans, 2000; Benkeblia, 2004 quoted in Istrati *et al.*, 2011). However, the microbial load obtained in the meat products in this study does not exceed \log_{10}^7 cfu/g/cm² at which microbial spoilage is detected in meat products as reported by Korkeala (1987) quoted in Kalalou (2010)

The thiobarbituric acid reactive substances (TBARS) values have been commonly considered as an index of lipid rancidity. The quantitative production of malonaldehyde during oxidation of fat in stored food is responsible for TBARS values. The level of malondialdehyde generated in meat/ stored meat products can be determined using the TBARS assay (Jo and Ahn, 1998).

The TBARS value in this study increased as the day of storage increased in all the packaging materials and this agrees with the report of Alam *et al.* (2005) that during storage the TBARS value increases due to the decomposition of the oxidized lipids. The study revealed that meat floss made from chevon had the highest TBARS, which implies that rate of lipid oxidation in chevon floss is higher than either beef or pork floss, This might be due to the fact that oil absorption was highest in chevon floss during preparation (oil is rich in polyunsaturated fatty acids). Also, despite its low lipid content compared to meat from other ruminants, chevon has a high proportion of unsaturated fatty acids in addition to being a source of conjugated linoleic acid (Webb *et al.*, 2005). Xiao *et al.* (2011) reported that several intrinsic and extrinsic factors, including the content and composition of unsaturated fatty acids and the concentration and activity of antioxidant substances in meat muscle can affect its oxidative stability. Mielnik *et al.* (2006) asserted that meat with high polyunsaturated and a high degree of linoleic fatty acids have accelerated oxidative processes. This support the report of Ahn *et al.* (1998) that the baseline lipid oxidation status of raw meat was a very important determinant of the progression of lipid oxidation in cooked meat.

The high TBARS value of chevon meat floss indicates that chevon floss has a shorter shelf life than beef or pork floss. This corroborates the report of Eega *et al.* (2005) and Lee *et al.*

(2005) that the shelf life of chevon products may be shorter than beef products due to higher lipid oxidation rate.

It would have been expected that pork, due to its high fat content, will deteriorate faster or have a higher oxidative rate than beef, but the result showed that pork floss had a low TBARS values in all the packaging media. This might be attributed to the fact that the unsaturated fatty acid found in pork is rich in monounsaturated fatty acid as compared to fats in other ruminants (Vandendriessche, 2008). The monounsaturated fats contain less sites for oxidation, which implies that the rate of lipid oxidation in pork floss will be low compared to other meat floss. Furthermore, pork possesses high saturated fat that is stable and less reactive. In contrary, the fats found in beef are located intramuscular and cannot be trimmed off and, being high in unsaturated fat, are susceptible to oxidation. Furthermore, the phospholipid found in beef is higher than that of pork. Reports had shown that phospholipids are considered to be responsible for about 90% of lipid oxidation (Pikul *et al.*, 1984; Buckley *et al.*, 1989).

During storage of the products it was observed that the TBARS value increased as the number of days increased in all the products and in all the packaging media. This corroborates the report of Singh *et al.* (2011) that oxidation increases as the period of storage increases.

Chapter Five

Yield and quality attributes of meat floss as influenced by muscles types

5.1 Introduction

Muscle is composed of a heterogenous mixture of fibre types, which differ in their biochemical and physical properties (Florek *et al.*, 2007). For example, bovine semitendinosus contains significantly higher proportion of white and intermediate fibres than biceps femoris, which contains a higher proportion of red fibres (Hertzman *et al.*, 1993). The red fibres have a higher concentration of myoglobin and are generally lower in glycogen and higher in lipid content than the white fibres (Florek *et al.*, 2007). The chemical and physical properties of muscle tissue and the associated connective tissue are very important when considering the usefulness of meat as food (Ahmed *et al.*, 2007). Therefore, providing information on particular characteristics of different parts of muscle will support the meat industry to use suitable muscle for production of specific product and also for marketing purposes (Hoffman *et al.*, 2008). Moreover, differences in muscle characteristics will determine the specific result of further processed meat products (Berri *et al.*, 2005; Petracci *et al.*, 2008). Hence, the aim of this study was to evaluate the effect of different muscle types of meat floss on yield, proximate composition and keeping quality of meat floss.

5.2 Materials and Methods

5.2.1 Sample collection

The muscles of meat used in this study were the semi tendinosus, semi membranosus and bicep femoris of a matured bull. The muscles were purchased from a commercial abattoir market in Ibadan, Nigeria. The muscles were excised from the carcass of singed animals within one hour postmortem.

5.2.2 Experimental design

The experimental design was completely randomized design (CRD). Each muscle represented each experimental treatment and each treatment was replicated three times.

5.2.3 Sample preparation

The muscles- semi tendinosus, semi membranosus and bicep femoris were trimmed off of all visible dirt, fats, connective tissues and ligaments and washed with cool clean water. They were cut into chunks of average weight of 100 g each. Thirty (30) chunks were randomly selected per muscle type to have three (3) kg of fresh meat for respective muscle type.

5.2.4 Preparation of meat floss

Meat floss was prepared from these muscle types as described in study two reported in Chapter Three.

5.2.5 Parameters measured

All parameters measured in study two on both raw meat and meat floss were also carried out on the raw muscles used and meat floss produced in this study. The score sheet for sensory evaluation is shown in appendix III.

5.2.5.1 Thiobarbituric Acid reactive Substances (TBARS)

The best packaging material in study 2 (polyethylene) was adopted for use in this study. Like in study 2, the TBARS were determined at days 0, 7, 14, and 21 of storage at room temperature. Similar procedure used in study 2 for TBARS determination was employed in this study.

5.2.5.2 Microbiological assay

The best packaging material in study 2 (polyrthylene) was used in this study and similar methodology was employed for microbial plate counts.

5.2.6 Statistical analysis

All data generated were compared using analysis of variance (ANOVA) and the general linear model procedure of the SAS System for Windows V8.01 (SAS Institute Inc., Cary, NC). Differences between group means were analyzed by Duncan's multiple-range test. Statistical significance was set at $P < 0.05$.

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5.3 Results

5.3.1 Physical characteristics of different muscles

The results presented in Table 20 showed the physical characteristics of different muscles of beef used for the production of meat floss. The cooking loss of semi tendinosus muscle (33.87%) was significantly higher ($P < 0.05$) than 29.94% and 29.26% for bicep femoris and semi membranosus muscles respectively. However, the thermal shortening of bicep femoris (23.21%) and semi tendinosus (22.47%) muscles were significantly higher ($P < 0.05$) than 20.87% obtained for semi membranosus muscles. The water holding capacity (69.41%) of bicep femoris muscle was significantly higher ($P < 0.05$) than 66.66% and 65.81% obtained for semi tendinosus and semi membranosus muscles respectively.

5.3.2 Proximate composition of the different muscles

The results displayed in Table 21 showed the proximate composition of the different muscles of beef used in meat floss production. The result revealed that the moisture and crude protein contents of the muscles significantly differed ($P < 0.05$) from each other. The moisture contents of becep femoris, semi tendinosus and semi membranosus muscles were 66.40%, 69.60% and 73.54% for respectively, and their crude protein contents were 23.30%, 22.84% and 22.34% respectively. The ash contents of semi membranosus (2.27%) and semi tendinosus (2.07%) were significantly higher ($P < 0.05$) than 1.56% obtained for bicep femoris muscle, while the ether extract of semi tendinosus was significantly higher ($P < 0.05$) than 1.99% and 1.95% obtained for bicep femoris and semi membranosus muscles respectively.

5.3.3 Meat yield and oil absorption of different muscles used for meat floss preparation

The yield and the quantity (%) of oil absorbed by the muscles during meat floss production is presented in Table 22. The result showed that the yield obtained from bicep femoris (64.12 g/100g) and semi membranosus (63.94 g/100g) muscles when used for the production of meat floss were significantly higher ($P < 0.05$) than 53.88 g/100g obtained from semi tendinosus muscle. The quantity of oil absorbed was highest when semi membranosus muscle was used for meat floss production in contrast to 17.00% and 15.35% recorded when bicep femoris and semi tendinosus muscles were used.

Table 20: Physical properties of different muscles used for meat floss production. Values are mean±SD (n=3).

Parameters	Bicep femoris	Semi tendinosus	Semi membranosus
Cooking loss (%)	29.94± 1.34 ^b	33.87± 0.96 ^a	29.26± 1.49 ^b
Thermal shortening (cm)	23.21± 2.53 ^a	22.47± 0.35 ^a	20.87± 1.23 ^b
Water holding capacity (%)	69.41± 1.36 ^a	65.81± 1.89 ^b	66.66± 1.17 ^{ab}

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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Table 21: Proximate composition of different muscles used for meat floss production. Values are mean±SD (n=3).

Parameters	Bicep femoris	Semi tendinosus	Semi membranosus
Moisture content (%)	66.40±3.98 ^c	69.60± 5.69 ^b	73.54± 1.05 ^a
Crude protein (%)	23.30±0.06	22.84±0.44	22.34± 0.33
Ash (%)	1.56±0.19 ^b	2.07±0.07 ^a	2.27± 0.07 ^a
Ether extract (%)	1.99±0.13 ^b	2.25± 0.15 ^a	1.95± 0.02 ^b

^{a, b, c} Means in the same row with different superscripts are significantly different (P<0.05)

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Table 22: Yield and percentage of oil absorbed by different muscles type during meat floss production (%). Values are mean±SD (n=3).

Parameters	Bicep femoris	Semi tendinosus	Semi membranosus
Yield (g/100g)	64.12± 0.38 ^a	53.88± 0.98 ^b	63.94± 0.26 ^a
Vol. of oil absorbed (ml)	17.00±1.17 ^b	15.35±2.73 ^b	21.77± 0.04 ^a

^{a, b, c} Means in the same row with different superscripts are significantly different (P<0.05)

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5.3.4 Proximate composition of the meat floss prepared from different muscles

The proximate composition of the meat floss prepared from different muscles of matured bull is shown in Table 23. The result revealed that the moisture retained in the meat floss from bicep femoris (19.87%) and semi tendinosus (19.64%) muscles were significantly higher ($P < 0.05$) than (17.46%) contained in product produced from semi membranous. The protein contents of the product from semi tendinosus (40.14%) and bicep femoris muscles were significantly higher ($P < 0.05$) than 36.58% obtained for semi membranous muscle. The ash contents of the products from the muscles did not differ ($P > 0.05$) from one another and the values were 2.16%, 2.49% to 2.62% for meat floss produced from bicep femoris, semi membranous and semi tendinosus muscles respectively. The ether extract contents of meat floss from semi tendinous (3.55%) was significantly higher ($P < 0.05$) than those of meat floss from semi membranous (2.61%) and bicep femoris (2.88%).

5.3.5 Sensory evaluation of meat floss prepared from different muscles

The results of the sensory evaluation of the meat floss from the three muscles as assessed by the panelists is presented in Table 24. The panelist rated meat floss produced from semi tendinosus muscle highest ($P < 0.05$) for flavour, tenderness and juiciness while for aroma, meat floss from bicep femoris and semi tendinosus muscles were similar ($P > 0.05$) but higher than the aroma score of 2.86 recorded for meat floss from semi membranous.

The flavour score and tenderness were similar ($P > 0.05$) with meat floss from bicep femoris and semi tendinous. Roppiness score ranged from 4.75 for meat floss from semi tendinosus to 6.75 for that of bicep femoris while semi tendinosus product had a score of 5.89. However, their texture score and overall acceptability ratings were statistically similar for meat floss from each of the muscle type used.

Table 23: Proximate composition of meat floss prepared from different muscles of matured bull. Values are mean±SD (n=3).

Parameters	Bicep femoris	Semi tendinosus	Semi membranosus
Moisture content (%)	19.87±1.09 ^a	19.64±0.94 ^a	17.46±1.16 ^b
Crude protein (%)	37.89±0.37 ^{ab}	40.14±1.03 ^a	36.58±0.99 ^b
Ash (%)	2.16±0.05	2.62±0.35	2.49 ±0.10
Ether extract (%)	2.88±0.09 ^b	3.55±0.12 ^a	2.61± 0.01 ^b

^{a, b, c} Means in the same row with different superscripts are significantly different (P<0.05)

Table 24: Sensory evaluation of meat floss prepared from different muscles of mature bull. Values are mean±SD (n=3).

Parameters	Bicep femoris	Semi tendinosus	Semi membranous
Aroma	3.78± 1.39 ^a	4.00± 0.50 ^a	2.86± 1.07 ^b
Flavor	4.88± 1.13 ^b	5.66± 1.73 ^a	4.55± 1.81 ^b
Tenderness	4.75± 1.49 ^b	5.33± 1.66 ^a	4.78± 2.22 ^b
Juiciness	4.56± 2.13 ^b	5.13± 1.64 ^a	3.44± 1.74 ^c
Texture	4.26± 1.11	4.33± 2.06	4.11± 1.53
Roppiness	6.75± 0.71 ^a	4.75± 2.44 ^c	5.89± 1.76 ^b
Overall Acceptability	6.40± 1.19	6.44± 1.24	6.44± 1.13

^{a, b, c} Means in the same row with different superscripts are significantly different (P<0.05)

5.3.6 Thiobarbituric acid reactive substances (TBARS) of meat floss prepared from different muscle types

The thiobarbituric acid reactive substances (TBARS) levels of meat floss produced from different muscle types is shown on Table 25. The result showed significant variations ($P < 0.05$) among the products when freshly prepared. The level found in meat floss produced from semi tendinosus (1.80 mg/100g) was significantly higher ($P < 0.05$) than 1.51 mg/100g found in bicep femoris, which was also significantly higher ($P < 0.05$) than 0.70 mg/100g found in semi membranous. The TBARS levels found at day 7 for meat floss prepared from bicep femoris (1.75 mg/100g) and semi tendinosus (1.89 mg/100g) were significantly higher ($P < 0.05$) than 0.87 mg/100g found in semi membranous. This same trend was noticed at day 14 where TBARS levels of products from bicep femoris (2.26 mg/100g) and semi tendinosus (1.94 mg/100g) were significantly higher ($P < 0.05$) than 0.94 mg/100g obtained from semi membranous muscle. Also on day 21, the TBARS levels found in both bicep femoris (2.23 mg/100g) and semi tendinosus (1.98 mg/100g) were higher ($P < 0.05$) than 1.04 mg/100g found in semi membranous.

Considering each of the products on each day of storage, the TBARS of meat floss prepared using biceps femoris and semi tendinosus followed a similar trend in days 0 and 7 of storage. The two products had TBARS that were lower at these two periods of storage than at later periods (14 and 21 days). In all the products, the TBARS was least at day 0 and increased progressively as the period of storage increased.

5.3.7 Total microbiological plate counts during storage of meat floss from different muscle types

The total plate counts of the different meat floss during storage is as shown in Table 26. The result revealed that at day zero, there were no significant difference ($P > 0.05$) in the microbial load of all the meat floss. The microbial loads were $1.43 \log 10^{-2} cfu/g/cm^2$, $1.53 \log 10^{-2} cfu/g/cm^2$ and $1.67 \log 10^{-2} cfu/g/cm^2$ for meat floss from bicep femoris, semi tendinosus and semi membranous respectively. However on day 7, there was significant difference ($P < 0.05$) in the microbial loads among the products. The microbial load found in meat floss

Table 25: TBAR substances (mg/100g) of beef meat floss from three different muscle types stored for 7, 14 and 21 days. Values are mean±SD (n=3).

Muscle Types	Storage Time (Days)			
	0	7	14	21
Bicep Femoris	1.51±0.05 ^{by}	1.75±0.12 ^{bx}	2.26±0.08 ^{ax}	2.23±0.05 ^{ax}
Semi-tendinosus	1.80±0.26 ^{bx}	1.89±0.23 ^{bx}	1.94±0.15 ^{ay}	1.98±0.13 ^{ay}
Semi membranousus	0.70±0.10 ^{cz}	0.87±0.04 ^{bz}	0.94±0.11 ^{bz}	1.04±0.11 ^{az}

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

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Table 26: Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of beef meat floss from three different muscle types stored for 7, 14 and 21 days. Values are mean \pm SD (n=3).

Muscle Types	Storage Time (Days)			
	0	7	14	21
Bicep Femoris	1.43 \pm 0.10 ^d	5.93 \pm 0.37 ^{cx}	15.07 \pm 0.44 ^{ax}	11.00 \pm 0.61 ^{bx}
Semi-tendinosus	1.53 \pm 0.21 ^d	3.73 \pm 0.17 ^{cz}	11.47 \pm 0.45 ^{ay}	8.93 \pm 0.36 ^{by}
Semi-membranosus	1.67 \pm 0.08 ^d	4.37 \pm 0.19 ^{cy}	6.97 \pm 0.24 ^{az}	7.67 \pm 0.19 ^{ay}

^{a,b,c,d} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

from bicep femoris ($5.93 \log 10^{-2} \text{cfu/g/cm}^2$) was significantly higher ($P < 0.05$) than $4.37 \log 10^{-2} \text{cfu/g/cm}^2$ (semi membranous) and this was also significantly higher ($P < 0.05$) than $3.73 \log 10^{-2} \text{cfu/g/cm}^2$ (semi tendinosus).

On day 14 of storage, the microbial load of meat floss from bicep femoris ($15.00 \text{ (cfu/g/cm}^2)$) was significantly higher ($P < 0.05$) than $11.47 \log 10^{-2} \text{cfu/g/cm}^2$ in semi tendinosus muscle, which was in turn significantly higher ($P < 0.05$) than $6.97 \log 10^{-2} \text{cfu/g/cm}^2$ in semi membranous muscle.

On day 21, the microbial load of meat floss from bicep femoris ($11.00 \log 10^{-2} \text{cfu/g/cm}^2$) was significantly higher ($P < 0.05$) than $8.93 \log 10^{-2} \text{cfu/g/cm}^2$ and $7.67 \log 10^{-2} \text{cfu/g/cm}^2$ obtained for products from semi tendinosus and semi membranous muscles respectively.

Considering the days of storage for each of the products, the total plate counts found in meat floss from bicep femoris on day 14 ($15.07 \log 10^{-2} \text{cfu/g/cm}^2$) and 21 ($11.00 \log 10^{-2} \text{cfu/g/cm}^2$) were significantly higher ($P < 0.05$) than $5.93 \log 10^{-2} \text{cfu/g/cm}^2$ found on day 7. Also, there is statistical variation ($P < 0.05$) among the microbial loads of meat floss from semi tendinosus muscles. The loads found at 14th day ($11.47 \log 10^{-2} \text{cfu/g/cm}^2$) was significantly higher ($P < 0.05$) than $8.93 \log 10^{-2} \text{cfu/g/cm}^2$ found at 21st day and this was also higher than $3.73 \log 10^{-2} \text{cfu/g/cm}^2$ found on the 7th day. However, for meat floss from semi membranous, the microbial load found on 14th day ($6.97 \log 10^{-2} \text{cfu/g/cm}^2$) and 21st day ($7.67 \log 10^{-2} \text{cfu/g/cm}^2$) were significantly similar ($P > 0.05$) but higher than $4.37 \log 10^{-2} \text{cfu/g/cm}^2$ found on 7th day.

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5.4 Discussion

The high cooking loss obtained for this study is an indication that the meat used has a low ability of retaining its water content when external forces is applied to it because the water holding capacity and cooking loss are inversely related. That is, the higher the cooking loss the lower the water holding capacity. This implies that the higher cooking loss of meat, the poorer its nutrient quality after cooking because during cooking most of the nutrients contained in such meat would be leached out into the broth.

The physical characteristics of the muscles showed that different muscles have different characteristics. The results obtained for cooking loss and water holding capacity for bicep femoris (29.94%, 71.11%) and semi membranosus (29.26%, 79.99%) were higher than (18.52%, 69.41%) and (20.70%, 66.66%) obtained by Omojola (2009) for bicep femoris and semi membranosus muscles respectively but the cooking loss value obtained for semi tendinosus (33.87%) was lower than 34.21% and 37.21% obtained by Preziuso and Russo (2004) for semi tendinosus muscle of beef slaughtered at 18-19 and 20-21 months respectively. The high cooking loss observed for semi tendinosus muscles could probably be due to its high intramuscular fat which might be leached out during cooking thereby increasing its cook out. This also corresponds with the report of Giovanna and Claudia (2004) that semi tendinosus muscle has a high cooking loss when compared to other muscles. But from Aaslyng *et al.* (2002) report, it would have been expected that semi tendinosus muscles will have a low cooking loss compared to other muscle because according to these researchers an increasing amount of intramuscular fat (IMF) also implies a decrease in cooking loss.

The moisture content obtained in this study (66.40%, 73.54%) for bicep and semi membranosus muscles are lower than (73.73%, 76.65%) and (72.48%, 74.48%) obtained by Omojola (2009) and de Almeida *et al.* (2006) for bicep femoris and semi membranosus muscles respectively while the value obtained for the semi membranosus (69.60%) was lower than 75.53% and 75.67% obtained by Presiuzo and Russo (2004) for semi tendinosus of animals muscle slaughtered at 18-19 and 20-21 months respectively. The protein content (20.97%, 21.17%) obtained by de Almeida *et al.* (2006) for bicep femoris and semi membranosus muscles respectively was lower than 22.34% and 23.30% obtained for similar muscles. The differences in the composition of the muscles could be attributed to the difference in the histochemical traits of the muscles because meat quality depends on the histochemical traits of the muscle from which it originates and

which makes various cuts derived from different anatomical locations to give meat with different quality characteristics (Ouali, 1990; Monin and Ouali, 1991; Klont *et al.*, 1998; Vestergaard *et al.*, 2000).

The bicep femoris muscle gave the highest yield which could be as a result of its high water holding capacity because yield and water holding capacity are directly related. The higher the ability of meat to retain its water during force application, the higher the yield of such meat. Sales and Horbańczuk (1998) reported that the total amount of saleable meat are influenced by its water holding capacity. Also, the fact that bicep femoris muscle absorbed much oil during meat floss preparation might have added to its weight. However, a collorary trend was observed in the meat yield from the semi tendinous because it had the least ability to hold on to its water during cooking resulting in high cooking loss and also absorbed the least oil during meat floss preparation.

The variation noticed in the chemical composition of the product could be attributed to the differences in the chemical composition in their respective raw meat form because the same treatment was allotted to them. It would have been expected that meat floss from semitendinosus should contain less nutrient compared to other meat floss because of its high cooking loss. It is assumed that most of the nutrients contained in meat with a high cooking loss would have been leached out during cooking but the reverse is noticed in this study. The high nutrient composition profile noticed in semi tendinosus could be as a result of coagulation of nutrients during cooking which will result in increase protein and fat contents of the meat. The result of the nutrient composition agrees with the report of Hodgson *et al.* (1991) that samples with high moisture content are likely to have higher percentages of protein and lower percentage of intramuscular fat and were likely to shrink much during cooking than samples with high intramuscular fat. Although no significant differences was noticed among the muscles in relation to crude protein, but numerically the protein content of semi membranous muscle was lower and it had lower percentages of cooking loss and shrinkage compared to other muscles.

The aroma of the products were scored low (all the values obtained were below intermediate value of 5), probably due to the presence of garlic that was perceived by the panelists because garlic contains vanilloids which is responsible for its pungent smell. As reported by Korczak *et al.* (2004), natural compounds such as spices/herbs used in food preparation, for preventing oxidation, may modify the nutritive value of food.

The meat floss from semi membranous muscles was scored the least in aroma probably due to its low intramuscular fat content compared to bicep femoris and semi tendinous (de Almeida *et al.*, 2006). The meat floss from semi tendinous was rated high in flavour, tenderness and juiciness probably due to its high intramuscular fat content because it is known that intramuscular fat may positively influence some organoleptic properties of meat such as tenderness, juiciness, flavour, etc. (Savell and Cross, 1988 quoted in Fiems *et al.*, 2000; Renand *et al.*, 2001). Although it would have been expected that the meat floss from the bicep femoris will be rated high in juiciness because of its high water holding capacity which is also a function of juiciness (Sales and Horbańczuk, 1998), but juiciness of meat does not only depend on its water holding capacity but also on the lipid content of the food.

Meat floss from bicep femoris and semitendinous were rated the least in tenderness. The low tenderness observed in meat floss from bicep femoris could be as a result of its high connective tissue. The connective tissue is a major contributor to the toughness of the meat. Honikel (1992) reported that muscles rich in connective tissue like biceps femoris are less tender than muscles containing less connective tissue. Despite the variability in the eating qualities of the products, all the meat floss were accepted to the panelists.

Generally, it was observed that the TBARS values increased as the period of storage increased. This agrees with the report of Pettersen *et al.* (2004) that TBARS increased during storage but the rate at which it occurred was low most probably due to the presence of antioxidants in some of the spices used. Reports have shown that reduction or inhibition of oxidative changes in lipids of meat and meat products may be the effect of the addition of antioxidants (Decker and Xu, 1998).

The results from this study revealed that microbial load of all products increased until the 14th day of storage before they decreased. This might be as a result of the anti microbial agents present in some of the spices used. Again this trend followed the microbial growth rate curve, which showed that microbes will increase until when the nutrient contents declined. It implies that most probably as at the 14th day of storage, the nutrient contained in each of the products to support active microbial growth have declined and the microbes started to die.

The high microbial load of meat floss from bicep femoris could be attributed to its high moisture and crude protein contents as compared to meat floss from semi membranous. Also, it is a

muscle that is made up of red fibres, and red fibre muscles are susceptible to microbial spoilage compared to white fibres muscles (Florek *et al.*, 2007).

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Chapter Six

6.0 Qualitative Differences and Similarities of meat floss prepared from different oil types

6.1 Introduction

Fats and oils play important functional and sensory roles in food products. They are responsible for carrying, enhancing and releasing the flavour of other ingredients as well as for interacting with other ingredients to develop the texture and mouth-feel characteristics of fried food (Giese, 1996). However, the type and quality of oil used for frying play important role in physicochemical and organoleptic changes (Jacobson, 1991), It also influences the quality and shelf life of fried products (Alabdulkarim *et al.*, 2012) because frying oils are absorbed by cooked food and so become part of the diet (Mihaela *et al.*, 2010) for instance, the degree of saturation of fat used for deep frying will be reflected in the fat contents of the food (Mehta *et al.*, 2001) and different oils have different nutrient components.

Furthermore, consumers demand healthier meat products that are low in salt, fat, cholesterol, nitrites and calories (Weiss *et al.*, 2010). The type of oil used in food preparation therefore is of major health concern to the consumer of the final product.

Meat floss production entails the use of oil in deep frying before the final product is obtained and there seemed not to be a standard, Different processors used different oils ranging from red palm oil to bleached palm oil and different types of vegetable oils available in the market. No premium is placed on the quality of oil used hence it becomes imperative to evaluate the quality of different oil types used in meat floss production.

The purpose of this study was to evaluate how deep fat frying of shredded meat in different vegetable oils affected the colors, keeping qualities (in terms of lipid oxidation microbial load) and organoleptic attributes of meat floss

6.2 Materials and Methods

6.2.1. Sample collection

The meats used for this study were the semi-tendinosus of a matured bull. This was purchased in a commercial abattoir within one hour postmortem to avoid the onset of rigor mortis of the muscles. The different oil types (soybean oil and groundnut oil - brand- grand[®] and palm oil) used in this study were purchased from a standard supermarket.

6.2.2. Production of meat floss

This was prepared as described in study two. The palm oil was bleached before using it for meat floss production. This was achieved by heating the oil to a temperature of 120°C and maintaining this temperature until the oil becomes almost whitish in colour. The meat samples were allotted to the different oil types immediately after cooking and cooling before shredding.

6.2.3 Experimental design

A completely randomized design was employed. The cooked meat samples were allotted randomly to the three experimental treatments represented by each oil types. Each treatment was replicated thrice.

6.2.4 Packaging

Three types of packaging materials were used in this study they include: Arcylic bottles, Polyethylene and Polyamide. Meat floss obtained from the different oil types were packaged into these three packaging media for preservation and further analysis.

6.2.5. Parameters measured

The parameters measured include the physico-chemical properties of the raw beef, proximate analysis of raw beef and the different beef floss, yield of the products, sensory evaluation of the beef floss, microbial counts and thiobarbituric acid reactive substances of the beef floss. The procedures used to determine these parameters in study two were also used here. The score sheet for sensory evaluation for this study is shown in appendix IV. Other parameters measured include:

6.2.5.1 Iodine value of the oil

The weight of iodine absorbed by 100 g of oil expressed in percentage is referred to as iodine value/number. The iodine values of the oils were determined using Wji's method as described by AOAC (1990).

6.2.5.2 Cholesterol determination

Total cholesterol was extracted from lyophilized meat floss (dried meat floss) after saponification with saturated methanolic potassium hydroxide (KOH). This was followed by extraction with cyclohexane (Ponte *et al.*, 2004). Cholesterol was separated and quantified by normal phase HPLC with an HPLC system equipped with an auto sampler and diode array detector adjusted at 206 nm. Total cholesterol content of each was calculated in duplicate based on the external standard technique from a standard curve area versus concentration.

6.2.6. Statistical analysis

All data generated were compared using analysis of variance (ANOVA) and the general linear model procedure of the SAS System for Windows V8.01 (SAS Institute Inc., Cary, NC). Differences between group means were analyzed by Duncan's multiple-range test. Statistical significance was set at $P < 0.05$.

6.3. Results

6.3.1. Physico-chemical properties, proximate composition and cholesterol content of the raw beef

Table 27 showed the physical properties, proximate composition and cholesterol content of the raw beef used for production of meat floss in this study. The result showed that raw meat used has a cooking loss of 26.23%, thermal shortening of 26.50% and the water holding capacity was 70.05%. The raw meat had 78.07%, 21.79%, 3.40%, 3.92% and 89.56% of moisture, crude protein, ash, ether extract and cholesterol contents respectively.

6.3.2. Iodine content of oils

The iodine values of the three oil types used in the production of meat floss are shown in Table 28. The results obtained revealed that the iodine values of groundnut oil (38.83%) and soya oil (36.17%) were not significantly different, and were significantly higher ($P < 0.05$) than 28.00% obtained for palm oil.

6.3.3. Yield, oil absorption and cholesterol contents of beef meat floss produced with different oil types

The results displayed on Table 29 is the yield, volume of oil absorbed and cholesterol contents of the meat floss produced with different oil types. The results showed that the yield of meat floss as gram per kilogram of raw meat obtained from groundnut oil (69.11 g/100g), soya oil (69.38g/100g) and palm oil (68.55g/100g), and the volume of oil absorbed in groundnut oil (20.24%), soya oil (21.17%) and palm oil (20.42%) were similar ($P > 0.05$). However, the cholesterol content of meat floss from palm oil (25.75%) was higher than that of meat floss from groundnut oil (21.75%) and soya oil (19.75%).

Table 27: Physical properties, proximate composition and cholesterol content of raw beef used for production of meat floss. Values are mean±SD.

Parameters	Values
Cooking loss (%)	26.33±1.59
Thermal shortening (%)	26.50±2.15
Water Holding Capacity (%)	70.05±3.64
Moisture (%)	78.07±0.75
Crude protein (%)	21.79±0.85
Ash (%)	3.92±0.53
Ether Extract (%)	3.40±0.68
Cholesterol (mg/100g)	89.56±0.86

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Table 28: Iodine values of groundnut, soya and palm oils used to produce beef meat floss. Values are mean±SD.

Parameters	Oil Types		
	Groundnut oil	Soya oil	Palm oil
Iodine values	38.83±0.76 ^a	36.17±0.76 ^a	28.00±1.00 ^b

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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Table 29: Yield, oil absorption and cholesterol content of beef meat floss produced with groundnut, soya and palm oils

Parameters	Oil Types		
	Groundnut oil	Soya oil	Palm oil
Yield (g/100g)	68.55±0.35	69.11±2.70	69.38±0.88
Volume of oil adsorbed (%)	20.24±1.92	21.17±2.87	20.42±0.59
Cholesterol (mg/100g)	21.75±0.85 ^b	19.75±0.35 ^c	25.75±0.65 ^a

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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6.3.4. Proximate composition of beef meat floss produced with different oil types

The proximate composition of the meat floss produced from three oil types are presented in Table 30. The results showed that there were no significant differences ($P>0.05$) in the crude protein (43.83%, 44.55%, 43.43%) and ether extract (11.19%, 10.59%, 9.85%) contents of the three products. The moisture contained in meat floss from palm oil (14.33%) was significantly higher ($P<0.05$) than the moisture content of meat floss produced using groundnut oil (11.38%) and soya oil (11.75%). The ash content of meat floss using from soya oil (7.21%) was significantly higher ($P<0.05$) than the 6.22% and 6.36% obtained from meat floss produced using groundnut oil and palm oil respectively.

6.3.5. The eating qualities of beef meat floss produced with different oil types

The eating qualities of meat floss produced from three oil types are shown in Table 31. The result revealed that no significant difference existed ($P>0.05$) in the colour of the three types beef meat floss, but the aroma of the meat floss produced from groundnut (5.11) was significantly higher ($P<0.05$) than 4.78 and 4.67 obtained for meat floss from soya and palm oils respectively. While meat floss produced from soya oil was best ($P<0.05$) in flavour (5.89) compared to 4.56 and 4.67 obtained for meat floss produced from palm and groundnut oils respectively. Meat floss produced from palm oil (6.44) was the most tender ($P<0.05$) compared to 5.33 and 5.00 obtained for meat floss produced from groundnut and soya oils respectively. The meat floss types were not significantly different ($P>0.05$) in juiciness (5.89, 5.78 and 4.78) and in overall acceptability (6.56, 6.33 and 6.11) of the meat floss produce using soya, groundnut and palm oils respectively.

6.3.6 TBARS and microbiology counts of freshly prepared meat floss from different oil types

The result as displayed on Table (32) showed that TBARS of meat floss from soya oil (0.82mg/100g) was significantly higher ($P<0.05$) than 0.42mg/100g and 0.46mg/100g obtained for meat floss from groundnut and palm oils respectively. Also, the microbial load of meat floss from soya oil ($1.49 \log_{10}^{-2}$ cfu/g/cm²) was significantly higher ($P<0.05$) than $1.18 \log_{10}^{-2}$ cfu/g/cm² and $1.27 \log_{10}^{-2}$ cfu/g/cm² recorded for meat floss from groundnut and palm oils respectively.

Table 30: Proximate composition of beef meat floss from groundnut, soya and palm oils

Parameters	Groundnut oil	Soya oil	Palm oil
Moisture (%)	11.38±0.38 ^b	11.75±0.49 ^b	14.33±0.41 ^a
Crude protein (%)	43.82±0.51	44.54±0.56	43.44±0.29
Ash (%)	6.22±0.30 ^b	7.21±0.59 ^a	6.36±0.60 ^b
Ether extract (%)	11.19±1.95 ^a	10.59±1.23 ^b	9.85±1.21 ^c

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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Table 31: Sensory evaluation of beef meat floss prepared from different oil types

Organoleptic properties	Meat floss from oil types		
	Groundnut	Soya	Palm
Colour	5.44±1.88	5.22±1.48	5.00±1.23
Aroma	5.11±1.97 ^a	4.78±1.99 ^b	4.11±1.83 ^b
Flavor	4.67±1.87 ^b	5.89±1.90 ^a	4.56±1.94 ^b
Tenderness	5.33±1.87 ^b	5.00±2.06 ^b	6.44±0.73 ^a
Juiciness	5.78±1.86 ^a	5.89±2.57 ^a	4.78±2.11 ^b
Overall Acceptability	6.33±1.73	6.56±1.51	6.11±1.36

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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Table 32: TBARS (mg/100g) and microbiological counts (\log_{10}^{-2} cfu/g/cm²) values of freshly prepared meat floss from different oil types

Parameters	Oil Types		
	Groundnut oil	Soya oil	Palm oil
TBARS (mg/100g)	0.42±0.25 ^b	0.82±0.06 ^a	0.46±0.30 ^b
Microbiological Count (\log_{10}^{-2} cfu/g/cm ²)	1.18±0.36 ^b	1.49±0.18 ^a	1.27±0.41 ^b

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

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6.3.7 TBAR substances (mg/100g) of beef meat floss from different oil types and differently packaged for 7, 14 and 21 days

Displayed on Table (33) is the result of the TBARS values of meat floss from different oil types differently packaged and stored for 7th, 14th and 21 days. The result revealed that irrespective of the type of meat floss and packaging media, the TBARS values obtained at 21st day for all the products were significantly higher ($P < 0.05$) than the values obtained at 7th and 14th days of storage. However, a slight deviation was noticed from this trend with the meat floss produced from Soya oil when it was stored in the polyethylene packaging media. The TBARS obtained for this product (1.39mg/100g; 1.45mg/100g) on 7th and 14th days respectively were significantly higher than ($P < 0.05$) than 1.21mg/100g obtained on 21 day. The result also showed that irrespective of the packaging media and days of storage with the exception on 7 day inside acrylic bottle and at day 21 inside polyethylene, TBARS values obtained for meat floss produced from Soya oils were significantly higher ($P < 0.05$) than the TBARS values obtained from meat floss produced from other oils.

6.3.8 TBAR (mg/100g) of meat floss from different oil types and differently packaged

The result on Table 34 is the values of TBARS of meat floss from different oil types when differently packaged. The result revealed that TBARS of products inside polyamide were significantly higher ($P < 0.05$) than the TBARS measured in any of the packaging media. However, all the products stored best ($P < 0.05$) in acrylic bottles than other packaging media except in the case of meat floss produced from palm oil whose TBARS levels both in acrylic bottles and polyethylene are not significantly different ($P > 0.05$).

Table 33: TBAR substances (mg/100g) of beef meat floss from different oil types and differently packaged for 7, 14 and 21 days. Values are mean±SD (n=4).

Packaging	Oil Types	Storage Time (Days)		
		7	14	21
Acrylic bottle	Groundnut	0.82±0.02 ^c	0.95±0.09 ^{by}	1.21±0.06 ^{az}
	Soya	0.91±0.14 ^c	1.05±0.16 ^{bx}	1.44±0.29 ^{ax}
	Palm	0.98±0.07 ^c	1.18±0.04 ^{bx}	1.34±0.21 ^{ay}
Polyethylene	Groundnut	1.05±0.17 ^{cy}	1.26±0.06 ^{by}	1.32±0.13 ^{ay}
	Soya	1.39±0.31 ^{bx}	1.45±0.41 ^{ax}	1.21±0.06 ^{cz}
	Palm	0.89±0.10 ^{cz}	1.10±0.05 ^{bz}	1.47±0.30 ^{ax}
Polyamide	Groundnut	1.07±0.21 ^{cy}	1.21±0.22 ^{by}	1.51±0.08 ^{ay}
	Soya	1.13±0.10 ^{cx}	1.58±0.42 ^{bx}	2.52±0.29 ^{ax}
	Palm	1.02±0.13 ^{by}	1.49±0.39 ^{ax}	1.44±0.32 ^{ay}

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

Table 34: TBAR substances (mg/100g) of meat floss from different oil types and differently packaged. Values are mean±SD (n=12).

Packaging Media	Oil Types			Packaging Mean
	Groundnut	Soya	Palm	
Acrylic Bottle	0.99±0.18 ^{bz}	1.13±0.30 ^{az}	1.17±0.19 ^{ay}	1.10
Polyethylene	1.21±0.17 ^{by}	1.55±0.34 ^{ay}	1.15±0.30 ^{cy}	1.30
Polyamide	1.27±0.25 ^{bx}	1.74±0.66 ^{ax}	1.31±0.35 ^{bx}	1.44
Oil Type Mean	1.16	1.47	1.21	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

6.3.9 Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of beef meat floss from different oil types and differently packaged

Shown on Table 35 is the microbial load of meat floss from different oil types differently packaged and stored for 7, 14 and 21 days. It was observed that the microbial load ($1.49 \log_{10}^{-2}$ cfu/g/cm²) of the meat floss from Soya oil on day 0 was significantly higher ($P < 0.05$) than the number of microbes found in meat floss produced from groundnut ($1.18 \log_{10}^{-2}$ cfu/g/cm²) and palm ($1.27 \log_{10}^{-2}$ cfu/g/cm²) oils. Irrespective of the storage media and products, the microbial load decreased with increase in days of storage. Also, when each of the products was stored in any of the packaging media, irrespective of the days of storage, it was observed that meat floss from Soya oil had the highest ($P < 0.05$) microbial load than meat floss from either groundnut or palm oils. Considering each of the products in the packaging media, it was observed that irrespective of the duration of storage, microbial loads of products inside polyamide were significantly higher ($P < 0.05$) the microbial load found inside Acrylic bottles and polyethylene. However, in each of the packaging media irrespective of the products inside it, there was no significant difference ($P > 0.05$) in the microbial load found in each of the product at 21 day of storage.

6.3.10 Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of meat floss from different meat types and differently packaged

The result displayed on Table 36 is the microbial load of meat floss from different oils types differently packaged. The result showed that irrespective of the packaging media, the microbial load of meat floss from Soya oil was significantly higher ($P < 0.05$) than the microbial load found in other products. Also irrespective of the products, the microbial load inside the polyamide were significantly higher ($P < 0.05$) than those found in acrylic bottles and polyethylene storage media.

Table 35: Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of beef meat floss from different oil types and differently packaged for 7, 14 and 21 days. Values are mean \pm SD of square root $(x+0.5)^{1/2}$ transformed data (n=4). De-transform using $(x^2-0.5)$.

Packaging Media	Oil Types	Storage Time (Days)		
		7	14	21
Acrylic bottle	Groundnut	1.73 \pm 0.59 ^{ax}	0.84 \pm 0.26 ^{by}	0.84 \pm 0.26 ^b
	Soya	1.70 \pm 0.39 ^{ax}	1.13 \pm 0.55 ^{bx}	0.84 \pm 0.26 ^c
	Palm	1.15 \pm 0.50 ^{ay}	1.06 \pm 0.42 ^{ax}	0.84 \pm 0.26 ^b
Polyethylene	Groundnut	1.35 \pm 0.50 ^{ax}	0.97 \pm 0.29 ^{by}	0.84 \pm 0.26 ^c
	Soya	1.49 \pm 0.18 ^{ax}	1.13 \pm 0.55 ^{bx}	0.84 \pm 0.26 ^c
	Palm	1.06 \pm 0.42 ^{ay}	0.97 \pm 0.29 ^{by}	0.84 \pm 0.26 ^c
Polyamide	Groundnut	1.47 \pm 0.31 ^{az}	1.22 \pm 0.66 ^{by}	0.97 \pm 0.29 ^c
	Soya	2.14 \pm 0.75 ^{ax}	1.52 \pm 0.95 ^{bx}	1.06 \pm 0.42 ^c
	Palm	1.61 \pm 0.46 ^{ay}	1.18 \pm 0.36 ^{bz}	0.97 \pm 0.29 ^c

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

Table 36: Microbiology counts (\log_{10}^{-2} cfu/g/cm²) of meat floss from different meat types and differently packaged. Values are mean \pm SD of square root $(x+0.5)^{1/2}$ transformed data (n=12). De-transformed using $(x^2-0.5)$.

Packaging Media	Oil Types			Packaging Mean
	Groundnut	Soya	Palm	
Acrylic Bottle	1.01 \pm 0.39 ^{cy}	1.22 \pm 0.53 ^{ay}	1.13 \pm 0.57 ^{by}	1.12
Polyethylene	0.95 \pm 0.32 ^{cy}	1.15 \pm 0.43 ^{ay}	1.05 \pm 0.40 ^{by}	1.05
Polyamide	1.25 \pm 0.44 ^{bx}	1.57 \pm 0.82 ^{ax}	1.22 \pm 0.44 ^{bx}	1.35
Oil Type Mean	1.07	1.31	1.13	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)

^{x,y,z} Means in the same column with different superscripts are significantly different (P<0.05)

6.4 Discussion

Cooking loss measures the amount of shrinkage expected upon cooking of a particular meat sample. This, apart from affecting the yield also affects the nutritive value of meat. The low value is expected that most of the nutrients contained in such meat would have been leached into the broth resulting in poor quality of such cooked meat. The cooking loss (26.23%) of the raw beef obtained in this study was slightly higher than the cooking loss of 24% obtained by Okubanjo *et al.* (2003) for Bunaji breed of cattle and 22.50% reported by Jeremiah and Gibson (2003), but does not exceed 30% reported by Razminowicz *et al.* (2006) in pasture feed-steers. The variability could be attributed to differences in the animals been evaluated in terms of marbling, breeds, etc (Nour *et al.*, 1994; Yu *et al.*, 2005).

The moisture, crude protein, ash and ether extract contents of the beef that were respectively 78.07%, 21.79%, 3.40% and 3.92% were slightly higher than 76.56%, 19.57%, 2.90%, and 1.50% obtained by Omojola *et al.* (2009) for beef used in the production of *Kundi*. The moisture and fat contents were higher than 73.10% and 2.80%, and the crude protein less than 23.20% obtained for Australian beef as reported by Sinclair *et al.* (1999). However, the crude protein obtained was similar to 21.87% reported by Solomakos *et al.* (2008), while the ether extract (2.47%) and moisture (72.27%) contents obtained by these researchers were slightly less than the values obtained in this study. The difference in the meat chemical composition could arise as a result of either the difference in age and breed (Okubanjo *et al.*, 2003), sex (Gašperlin *et al.*, 2006) and nutrition of the animal from which the muscles were obtained. Generally, this corroborates the report of Okubanjo *et al.* (2003) that different breeds of cattle possess different meat characteristics.

The yields of meat floss from the different oil types were similar (68.55%, 69.11%, 69.38%). The amounts of oil absorbed by meat floss during frying were also similar, which might have accounted for the similarities in their yield percentages.

Iodine value is measure the degree of unsaturation of oil. The higher the iodine number, the higher the degree of unsaturation which implies that such oil contains more of double bonds (polyunsaturated fatty acids). The iodine values obtained for the different oil used in this study indicate that palm oil had a lower degree of unsaturation compared to either groundnut oil or soya oil and this was reflected in their fatty acids proportion, that is, the typical composition of

the oils (soya oil - 15% saturates, 85% unsaturates; groundnut oil - 22% saturates and 78% unsaturates; palmoil 50% saturates and 50% unsaturates).

The difference in the nutrient composition of meat floss could be ascribed to the difference in the chemical composition of the oils used because a fried product will assume the nutrient composition of the frying medium (Fillion and Henry, 1998). The moisture content (11.38%-14.17%) obtained for meat floss in this study is lower than 33.40-39.81% contained in *Kundi* as reported by Omojola *et al.* (2009). The lower moisture content obtained could be attributed to the fact that production of meat floss is a dehydration process which means water and water soluble substances are extracted from the product during the deep frying and transferred to the cooking fat (Choe and Min, 1997).

The increase in the protein content of the products could be a result of reduction of its moisture content because water is a nutrient diluent. The less the water, the higher the protein content. The increase in protein content may also be due to the conformational changes of proteins, which might have occurred on heating. The heating brought about denaturation, followed by structural changes referred to as protein-protein interactions, which result in the aggregation of proteins (Tornberg, 2005). The increase in protein content observed for meat floss agrees with the report of Egbunike and Okubanjo (1999), that intermediate moisture meat are meats low in moisture content and contain three to four times the raw protein equivalent hence they are less bulky. The crude protein obtained in this study was lower than 69.80%-72.10% obtained by Soniran and Okubanjo (2002) for pork loin roast-cooked to an internal temperature of 65°C - 85 °C. The protein value (43.43%- 44.55%) obtained for meat floss in this study is also lower to the values of 52.29%, 58.89%, 53.42% obtained in *kundi* made from beef, camel and chevon respectively (Omojola *et al.*, 2009).

The increase in ash contents could be attributed to the heat treatment which the products were subjected. Igene and Ekanem (1985) reported that ash content of meat increases during heat application. The ether extract contents of meat floss obtained in this study increased and was higher than 3.80-4.60% obtained by Omojola *et al.* (2009) for *kundi*. The deep frying stage in the production of meat floss might explain the increase in fat content of the product. Abiona *et al.* (2011) reported that during frying as water molecules are released, the product being fried absorbs the surrounding fat to compensate for the loss of water at the surface.

In a retail environment, colour is a critical sensory characteristic of meat as it is experienced by consumers before tenderness or flavour and tends to be used as an indicator of perceived quality and freshness (Carpenters *et al.*, 2001). Colour is one of the key quality attributes of meat and processed meat products (Cierach and Stasiewicz, 2007). Therefore, colour is probably the single greatest appearance factor that determines whether meat will be purchased (Florek *et al.*, 2007). The most important factors that determine the colour quality of processed meat products include recipe, contents of nutrients, pH, molecular pressure of oxygen, water activity, packaging method, storage temperature, air humidity, access of light and oxygen, type of package used, and permeability of gases (Cierach and Stasiewicz, 2007).

It would have been expected that meat floss from palm oil will have different colour compared to meat floss from other oils because of the presence of beta carotene, which accounts for the reddish colour of the oil. The colour of palm oil has been removed during bleaching of the oil before being used for meat floss production. Generally, the desirable colour of shredded meat is golden brown; and any difference in colour characteristic is contributed by the ingredients and frying temperature (Lin *et al.*, 1999). The colours of meat floss from the three oils were acceptable to the panelists most probably because during preparation, similar ingredients were used and upon frying, care was taken to stop immediately the golden brown colouration was achieved.

The eating quality which is a combination of tenderness, flavour and juiciness is one of the most important characteristics by which consumers judge meat quality (Grunert *et al.*, 2004), and one of the attributes that is most difficult to evaluate before purchase because it is not visible and highly variable (Verbeke *et al.*, 2010).

Aroma and flavour are quite subjective characteristics of meat that are difficult to evaluate by the panelists compared to many other traits like texture, temperature and pH that are measurable in more exact way (Poławska *et al.*, 2011). Aroma perception is usually mediated by the olfactory sense while flavour is perceived by the sense of taste and usually felt in the mouth. The aroma of meat floss from groundnut oil is more preferable to the panelist than those of meat floss from other oil types. This might be due to the distinctive appealing characteristic odour of groundnut oil that is easily perceived at a distance. The flavour of meat floss from soya oil was more preferable to the panelists, with the score rating above average (5.89) and higher than 4.67 and

4.56 scores obtained for meat floss produced from groundnut and palm oils respectively. This might be attributed to the fact that it has high fat content because the flavour of a product is fat dependent. Also, its high flavour score may also be a result of its high protein content (44.55%) compared to 43.83% obtained for meat floss from groundnut oil.

Risvik (1994) described tenderness as one of the main meat quality attributes important for its acceptability and purchasing intention of consumers. Tenderness as a trait consists of such elements as ease of shearing or cutting during mastication (Cooper and Horbańczuk, 2002). It was expected that the beef meat floss from either groundnut or soya oil will be more tender because both oils contain appreciable amount of polyunsaturated fatty acids which ought to make the product to be soft compared to product from palm oil, but the reverse is the case because the panelists rated meat floss from palm oil as best in tenderness. However, the juiciness of both meat floss from groundnut oil and soya oil was rated high numerically by the panelists as the best. This may be accounted for by the presence of high level of polyunsaturated fatty acids in the two oils.

In overall acceptability, the meat floss from the three oils were scored above intermediate (6.33, 6.56, 6.11), and were rated almost the same in acceptability by the panelists.

It was expected that the freshly prepared products should not contain microbes, especially because of its exposure to high temperature during frying, but some microbes were recorded in the product when freshly prepared. These microbes are assumed to be thermophilic which bypassed the high heat treatment that the products were subjected to during processing. Also, such microbes could arise because the environment is not void of microbes, which can get into product from the air during cooling or through the clothes worn during the processing of the product.

The high microbial load of meat floss produced using soya oil can be attributed to the presence of high nutrient profile of the product. The product from soya oil had high protein and ash contents and second in moisture and ether extract contents. This high nutrient content may indicate that the product from soya oil had abundant available nutrients for microbial growth.

The high microbial load of the products in polyamide may be attributed to the fact that the medium is prone to easy damage, which will make it permeable to oxygen, light and moisture. These factors will aid the growth of aerobic microbes and make them to proliferate rapidly. Since

the product may contain some anaerobic microbes, the proliferation of aerobic microbes in the medium will cause an increase in microbial load unlike polyethylene and acrylic bottle which are assumed to be air tight and are assumed to contain only anaerobic microorganisms.

The later decline in the microbial load during storage may be attributed to some of the spices used as flavouring agents (e.g. cloves and thyme) that contain phenolic compounds which have antimicrobial properties (Davidson and Naidu, 2000; Elgayyar *et al.*, 2001; AbdEl-Hamied *et al.*, 2009). It may be assumed that the phenolic compounds that were released during storage retarded growth and proliferation of the microbes. Generally, the reduced microbial load obtained in this study agrees with the report of Oke *et al.* (2009) that plant extracts and essential oils constitute a natural source of antimicrobial mixtures or pure compounds and these are used as natural agents to prevent the growth of food borne bacteria and moulds in food system as well as resulting in extension of the shelf life of processed foods.

The thiobarbituric acid reactive substances (TBARS) measurement is routinely used as an index of lipid oxidation in stored meat products. The result obtained in this study showed that the rate of lipid oxidation in the product was high in the meat floss produced using soya oil as it recorded the highest TBARS values. The low TBARS, hence low lipid oxidation rate in palm oil might be attributed to the fact that palm oil contains equal number of saturated and unsaturated fatty acids (50% saturated and 50% unsaturated fatty acids), unlike groundnut oil which contains 22% saturated and 78% unsaturated fatty acids, and soya oil which contains 15% saturated and 85% unsaturated fatty acids. Furthermore, the low TBARS in products from groundnut oil, despite its high unsaturated fatty acids may be due to the fact that the unsaturated fat is more of monounsaturated fatty acids. Groundnut oil contains 49% monounsaturated and 29% polyunsaturated fat, unlike 23% monounsaturated and 62% polyunsaturated found in soya oil. Also like groundnut oil, palm oil contains more monounsaturated fatty acids (40% monounsaturated and 10% polyunsaturated).

Furthermore, the presence of high monounsaturated fatty acids implies that such oil will contain low sites for reaction with other compounds. That is, it has more of single double bond sites and will be less susceptible to lipid oxidation unlike when the oil contains more polyunsaturated fatty acids which indicate more of double bond sites for reaction to occur. Though the results of iodine values for groundnut oil and soya oil were not different, the two oils have a high degree of

unsaturation compared to palm oil, which may indicate that they will be more susceptible to lipid oxidation than palm oil.

Furthermore, the susceptibility of soya oil to lipid oxidation could also be attributed to the fact that it contains a high proportion (7-10%) of oxidation-prone linoleic acid, a fatty acid which makes it less stable and sensitive to oxidation (USDA, 2004). This agrees with the report of Ghita *et al.* (2010) that polyenoic acids, such as linoleic acid, are much more sensitive to oxidation and the rate of peroxide formation is much rapid. The low susceptibility of palm oil to lipid oxidation could also be traced to its high content of vitamin E (tocopherol) which is a natural antioxidant (Zagre and Tarini, 2001). This might have accounted for the stability of palm oil (Sundram *et al.*, 2002). This result also agrees with the report of Ghita *et al.* (2010) that different oils have different rate of lipid oxidation because of the difference in their degree of saturation and that oil high in linoleic acid are much more sensitive to lipid oxidation.

Generally, it was observed that the rate of lipid oxidation increases as the day of storage increases which corroborates the report of Singh *et al.* (2011) that TBARS increases as the number of days of storage increases. Nevertheless, in this study all results obtained at three weeks of storage of the products indicated that the products are still consumable because the TBARS value obtained does not exceed the threshold/critical value of 3 mg/kg at which rancidity is observed in stored meat products as reported by Wong *et al.* (1995). Also, the slow rate of the lipid oxidation could be attributed to some antioxidants, which may be present in some of the spices used (Wang *et al.*, 1996). Esmat and Ferial (2010) reported slow rate of lipid oxidation during storage of meat steaks when various antioxidants were used.

The high TBARS value obtained for products in polyamide packaging medium might be due to entry of air, as the material may not be air tight as assumed for polyethylene and acrylic bottles. Therefore, the product stored in polyamide is prone to damage because oxygen contained in the air received will aid the rate of lipid oxidation, thereby increasing the value of TBARS of the products. Oxygen is the most common and essential component for the progress of lipid oxidation (Ahn *et al.*, 1992).

CHAPTER SEVEN

Summary and Conclusion

7.1 Summary

In this study, meat floss was developed from beef, chevon and pork.. A total of four studies were conducted to evaluate the qualities of meat floss.

In study one, the socio-economic baseline survey of meat floss production and consumption were carried out in four major cities (Abuja, Ibadan, Lagos and Kaduna). The results obtained showed that the producer of meat floss were mainly Hausa and mostly full house wives. They were all married with low level of educational background and have been in the business for more than 5 years. They used the semi tendinosus part of cow for meat floss production and they make as much as twice the cost of production as profit. Most of them do not have a ready market for their product and they stored the leftovers in containers. Consumers of meat product in the four cities were mostly male, aged between 26-40 years. They were mainly civil servants with high level of education. Most respondents purchase beef and employed freezing as a method of preservation at homes. Most of the consumers in Lagos and Ibadan were not familiar with meat floss and their first contact with the product was at parties. To most of the respondent the cost of the product is relatively cheap but were concerned about the hygiene and packaging of the product.

Quality attributes of meat floss produced from beef, chevon and pork were assessed in study two. The results showed that chevon gave the highest yield while pork gave the least. There were variations in the proximate composition of the different meat floss especially in the crude protein profile. Chevon gave the highest crude protein. There were noticeable increase in the proximate composition of the product indicating that the product is nutrient dense. There was variability in the overall acceptability of the products but all were well accepted to the panelists. Meat floss produced from chevon had the highest TBARS value while that produced from pork had the least value during storage. The microbial load of the products were also low.

The nutrient composition and keeping quality of meat floss produced from bicep femoris, semi tendinosus and semi membranous muscles of matured bull were evaluated in study three. The results obtained revealed that the yield of meat floss produced from bicep femoris was the highest while that produced from semi tendinosus was the least. The protein contents of the products increased as much as twice the protein content of the correspondent raw meat. The sensory parameters evaluated showed that there were variation in aroma, juiciness and tenderness among the meat floss produced from these muscles, but despite these variability, all the products were well accepted to the panelists. During storage, the meat floss produced from bicep femoris had the highest TBARS while that produced from semi membranous was the least and the total microbial counts for all the products were also low.

In the fourth study, nutrient composition, eating and keeping qualities of meat floss produced using different oil types (groundnut oil, soya oil and palm oil) were assessed. The result obtained showed that there were no differences in the yield of the products from the three types of oils. Meat floss produced when Soya oil was used gave the highest nutrient profile. There were also noticeable increases in the nutrient composition of the products. There were variability in the aroma, juiciness, tenderness flavour and acceptability among the products but all the products were accepted to the panelists. The product produced from soya oil had the highest TBARS during storage irrespective of the packaging medium. Polyamide (Nylon) kept any of the products with the highest TBARS value irrespective of the storage time. Despite this, all values obtained for TBARS did not exceed 3mg/100g at which rancidity is detected in stored meat products.

7.2 Recommendation

- ❖ Meat floss from chevon gave the highest yield in this study, therefore further studies could be carried out using other meat types that were not used in this study for meat floss production.
- ❖ The ingredients used in meat floss production varied among individuals. It is therefore recommended that the ingredients used in meat floss production should be standardized.
- ❖ This study observed that meat floss contained about twice the protein equivalent in raw meat per unit weight. It is recommended that further studies be carried out to determine the mineral and vitamin present in meat floss.
- ❖ It is also recommended that other packaging materials not used in this study could be exploited.

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UNIVERSITY OF IBADAN

APPENDIX I

Questionnaire for production pattern of meat floss

UNIVERSITY OF IBADAN

DEPARTMENT OF ANIMAL SCIENCE

This questionnaire is designed as part of the data collection for my Ph. D. Thesis. It is aimed at evaluating the production pattern of meat floss in Nigeria. Your input/cooperation will be highly appreciated. Thank you.

SECTION A

Please tick the most appropriate

1. Sex: male () Female ()
2. Average Age 15-25() 26-40() 41 and above ()
3. Marital Status Single () Married ()
4. Tribe Hausa () Igbo () Yoruba () Ijaw () Others ()
5. Religion Christianity () Islam () Traditional ()
6. Occupation Civil Servant () Trader () Others ()
7. Place of Residence Please specify
8. Level of Education Non formal () Primary ()
Secondary () Tertiary ()
9. Range of Income per month #5,000-10,000 #11,000-20,000, #21,000-40,000, above #40,000
specify range

SECTION B

10. What species of fresh meat do you usually buy in the market?
Beef () Pork () Poultry () Chevon (goat) Others specify ()
11. How regularly do you buy meat?
Everyday () Weekly () Fortnightly ()
Monthly () Quarterly ()
12. What type of meat do you prefer for processing?

- Beef () Chevon () Pork () Poultry ()
13. What part of the animal do you prefer for your production?
Shoulder meat () Thigh () Back () Others specify
14. How regularly do you buy meat for processing?
Daily () Weekly () Fortnightly () Monthly ()
15. At what price?
Less than #2,500 () #2,500-#5,000 () #5,000-#10,000 above #10,000
16. In the processing of meat which ingredients are a must?
Onions () Red pepper () Salt () Maggi ()
Groundnut oil () Cloves ()
17. Can you say processed meat production is a profitable venture? Yes () No ()
18. If Yes, how much do you make per production of raw meat?
2 times production cost () 3 times production cost ()
4 times production cost () Others specify ()
19. Do you have a ready market for your products? Yes () No ()
20. Do you dispose off all the quantity prepared daily? Yes () No ()
21. If no, how do you store the left over?
In the refrigerator () In the room (wrapped in a paper) ()
In a sealed container ()
22. How long can you keep the left over without it going bad?
0-1 month () 2-3 months () 3-4 months ()
4-5 months () above six months ()
23. What are the major constraints faced in the production of shredded meat/ Danbunama?
Processing is cumbersome () It is time consuming ()
Spices are not readily available () High cost of meat ()
Products do not last on the shelf ()
24. Which stage of production process do you wish to be improved? Please state
.....
25. If the constraints are removed would you produce more? Yes () No ()

APPENDIX II

Questionnaire for consumption pattern of meat floss

UNIVERSITY OF IBADAN

DEPARTMENT OF ANIMAL SCIENCE

This questionnaire is designed as part of the data collection for my Ph. D. Thesis. It is aimed at evaluating the consumption pattern of meat floss in Nigeria. Your input/cooperation will be highly appreciated. Thank you.

SECTION A

Please tick the most appropriate

1. Sex: male () Female ()
2. Average Age 15-25() 26-40() 41 and above ()
3. Marital Status Single () Married ()
4. Tribe Hausa () Igbo () Yoruba () Ijaw () Others ()
5. Religion Christianity () Islam () Traditional ()
6. Occupation Civil Servant () Trader () Others ()
7. Place of Residence Please specify
8. Level of Education Non formal () Primary ()
Secondary () Tertiary ()
9. Range of Income per month #5,000-10,000 #11,000-20,000, #21,000-40,000, above #40,000
specify range

SECTION B

10. What species of fresh meat do you usually buy from the market?
Beef () Pork () Poultry () Chevon (goat) Others specify ()
11. How regularly do you buy meat?
Every day () Weekly () Fortnightly ()
Monthly () Quarterly ()
12. If daily/weekly why?

- Poor refrigeration () The market is within reach () I like going to market every week () I don't like frozen meat ()
13. What quantity of meat do you buy at each purchase?
1-2kg () 2-3kg () 3-4kg () 4kg and above ()
14. How do you preserve such meat when purchased?
Freezing () Drying () Roasting () Salting ()
15. How do you process your meat when bought?
Salt and dry () Cut and smoke () Boil and Fry () others specify ()
16. Do you normally purchase processed meat products? Yes () No ()
17. If which ones Yes, how much do you make per production of raw meat?
Sliced Roasted Beef (Suya) () Sliced Dried Beef (Kilishi) ()
Roasted Chicken () Barbecue () Others specify ()
18. How much of these do you purchase in a month? (Give value in kg)
19. What time of the day do you buy processed meat?
Morning () Afternoon () Evening () Anytime () What
20. When do you consume the product after purchase?
Immediately () Later same day () Days later ()
21. Do you consume meat alone? Yes () No ()
22. With other snacks? Yes () no ()
23. Would you readily buy processed meat available in the shop? Yes () No ()
24. If No, state your reasons
25. Have you ever heard of a meat called Meat floss/Shredded meat/Danbunama? Yes () No ()
26. What is the local name for shredded meat in your dialect?.....
27. Have you tasted it before? Yes () No ()
28. If Yes how often? Once in a while () frequently ()
29. Where did you first see or taste the product?
North () South () East () West ()
Others specify ()
30. How did you see the product for the first time?
Served as snacks at a party () Displayed in a shop/at market place ()
Hawked at motor parks ()
31. What do you think of the cost of the product? (shredded meat)
Expensive () Fair () Cheap ()

32. What were your misgivings about the product?

The type of meat used () The type of spices used ()

Packaging () Hygiene ()

33. Is shredded meat available in your locality? Yes () No ()

34. If yes, is it being processed/produced in your area? Yes () No ()

35. If the product is produced and packaged better would your consumption level increase?

Yes () No ()

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Sensory evaluation score sheet

Appendix III

Name Sample No.....

Instruction: Please tick your level of preference for each trait of the given sample

Score	Aroma	Flavour	Tenderness	Texture	Juiciness	Roppiness	Overall acceptability
1	Not perceptible	Not perceptible	Extremely tough	Extremely coarse	Extremely dry	Extremely hot	Dislike extremely
2	Just perceptible	Just perceptible	Very tough	Very coarse	Very dry	Very hot	Dislike very much
3	Moderately perceptible	Moderately perceptible	Moderately tough	Moderately coarse	Moderately dry	Moderately hot	Dislike moderately
4	Slightly perceptible	Slightly perceptible	Slightly tough	Slightly coarse	Slightly dry	Slightly	Dislike slightly
5	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
6	Slightly strong	Slightly strong	Slightly tender	Slightly fine	Slightly juicy	Strongly not hot	Like slightly
7	Strongly intense	Strongly intense	Moderately tender	Moderately fine	Moderately juicy	Slightly not hot	Like moderately
8	Slightly intense	Slightly intense	Very tender	Very fine	Very juicy	Not hot	Like very much
9	Extremely intense	Extremely intense	Extremely tender	Extremely fine	Extremely juicy	Extremely not hot	Like extremely

Sensory evaluation score sheet

Appendix IV

Name Sample No.....

Instruction: Please tick your level of preference for each trait of the given sample

Score	Colour	Taste	Flavour	Texture	Juiciness	Overall acceptability
1	Dark	Extremely bitter	Not perceptible	Extremely coarse	Extremely dry	Dislike extremely
2	Just dark	Just bitter	Just perceptible	Very coarse	Very dry	Dislike very much
3	Moderately dark	Moderately bitter	Moderately perceptible	Moderately coarse	Moderately dry	Dislike moderately
4	Slightly dark	Slightly bitter	Slightly perceptible	Slightly coarse	Slightly dry	Dislike slightly
5	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
6	Slightly light	Just Sweet	Slightly strong	Slightly fine	Slightly juicy	Like slightly
7	Moderately light	Slightly sweet	Strongly intense	Moderately fine	Moderately juicy	Like moderately
8	Very light	Very sweet	Slightly intense	Very fine	Very juicy	Like very much
9	Extremely light	Extremely sweet	Extremely intense	Extremely fine	Extremely juicy	Like extremely